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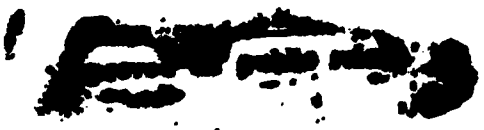
BIENNIAL REPORT ON LONG-TERM DOSE-RESPONSE STUDIES OF INHALED OR INJECTED RADIONUCLIDES

1991 - 1993

by the Staff of the
Inhalation Toxicology Research Institute
and the Radiobiology Division,
University of Utah School of Medicine



ITRI

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OCTOBER 1, 1991 through SEPTEMBER 30, 1993

by the
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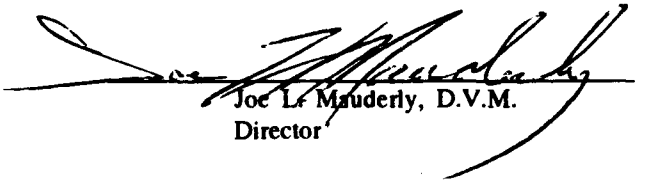
FOREWORD

This is the fourth report focussed specifically on the life-span dose-response studies being conducted at the Inhalation Toxicology Research Institute, ITRI, and the University of Utah. The first three of these reports were annual reports covering fiscal years 1989, 1990, and 1991. The reporting period for this report is biennial, covering fiscal years 1992 and 1993. These reports continue the tradition of presenting an historical record of these life-span studies in annual reports.

The information in this report is current through September 30, 1993. To ensure stand-alone quality for this report, a substantial amount of information is provided about the experimental design and methods as well as references to past results and the presentation of recent results and current status reports.

This report contains current information on the life-span studies initiated at ITRI, University of Utah, and Argonne National Laboratory. The inclusion of results from the Utah studies reflects the cooperative effort among investigators at ITRI and Utah to complete the Utah studies. Included in this effort are the husbandry, clinical care, and biomedical observations of living Utah-study dogs at ITRI. Similar care and observations are being provided to all the living dogs in the life-span studies of Beagle dogs that were irradiated chronically with gamma radiation from an external source at Argonne National Laboratory until being transferred to ITRI on January 23, 1991.

Most of the studies initiated at the University of Utah or ITRI have reached the point where all dogs on study are now dead. Thus, most of the current effort is being directed toward detailed reviews and analyses of study materials and data followed by the publication of these results in the open scientific literature. Teams of investigators at both institutions are conducting the necessary reviews and analyses and publishing the related core manuscripts on each study. The results given in these basic manuscripts provide the basis for dose-response analyses to assess the health-risk implications for possible accidental human exposure. As the results from more studies become available, increasing effort will be devoted to health risk analyses across studies within a laboratory and also across studies in other laboratories. An Executive Summary briefly summarizes recent progress and accomplishments and the types and location of various data tables and charts related to these studies.



Joe L. Mauderly, D.V.M.
Director

EXECUTIVE SUMMARY

This report describes the scientific progress in, and current status of, life-span studies of the long-term health risks in Beagle dogs of chronic irradiation from internally deposited radionuclides or from an external source. The reporting period for this document is the 2-year period from October 1, 1991 through September 30, 1993. Studies that were initiated at three different laboratories (Inhalation Toxicology Research Institute, ITRI, University of Utah, and Argonne National Laboratory, ANL) are presented here because they are being completed at ITRI.

All living dogs in the Utah-initiated studies were transferred to the ITRI facility for the remainder of their life-span observations and measurements in September 1987. Scientists at both institutions are working collaboratively to ensure the orderly and thorough completion of these studies. This report is the fourth in a series of annual or biennial reports dealing with the current status and progress of both the Utah and ITRI studies.

Other life-span studies involving dogs exposed to gamma radiation from an external source were initiated and conducted for many years at ANL. In 1991, the decision was made to discontinue the chronic irradiation of the remaining living dogs and to transfer all remaining dogs to ITRI for care, clinical observations, and pathological observations at death or euthanasia. This report provides the current status of these dogs.

Status reports on the Utah and ITRI studies comprise most of this report. The information on both sets of studies is organized along similar lines, addressing basic research approaches, study designs, recent accomplishments, and progress in study-completion activities.

The ITRI-related section presents brief statements of project objectives, the general procedures used in these studies, and some study-specific features for each of the 19 studies being conducted with either beta- or alpha-emitting radionuclides. Dose- and effect-modifying factors being addressed in these studies include total dose, dose rate, LET, solubility, nonuniformity of dose, species, age, sex, health status, and mode of exposure. Recent additions to experimental protocols for studies in which dogs are still alive involve the collection and analysis of tumor tissues using currently available molecular biology techniques.

The ITRI section continues with a presentation on the current status of these studies divided into four sections dealing with 1) studies in which dogs are alive, 2) studies in which all dogs are dead, 3) current activities related to completion of all these studies, and 4) recent research accomplishments. On September 30, 1991, 106 dogs were alive in six studies. On September 30, 1993, the closing date for this report, the number of living dogs was 49 in four studies. All of the remaining dogs were exposed by inhalation to monodisperse particles of $^{239}PuO_2$ either once or repeatedly as young adult dogs or once as immature dogs. Brief clinical and pathology summaries are given in a manner consistent with past reports for each dog that died during the reporting period. For readers wishing to study past reports on studies in which all dogs are dead, summary information and references are given to all previous reports on these studies in past annual reports.

Much of the current effort on the ITRI studies is directed to completion of the clinical pathology reviews of the dogs by study, data analyses, and manuscript preparations needed to determine and present the basic results of these studies and their implications for human health risks from inhaled radionuclides.

Five brief reports are presented as examples of efforts underway in these studies. The first of these reports examines the long-term carcinogenic responses seen in the four studies in which dogs inhaled, or were injected with, soluble forms of beta-emitting radionuclides. Attention was directed specifically to the primary target organs, lung, liver, bone, and nasal mucosa. Differences in tumor incidence among these organs related to differences in radionuclide distribution patterns among these radionuclides. Further dose-response analyses will be conducted to provide more quantitative information on these similarities and differences.

Bone tumor incidence in all ITRI studies involving soluble or relatively soluble forms of radionuclides ($^{90}SrCl_2$, $^{91}YCl_3$, $^{144}CeCl_3$, $^{137}CsCl$, and $^{238}PuO_2$) is addressed in the second report. Comparison of the number of bone tumors observed in these studies with various beta- or alpha-emitting radionuclides suggests that the tumors occurred primarily in studies with the longer-lived radionuclides. Significant differences were observed in the distribution of tumors within the skeleton and the occurrence of possible bone-associated tumors. Further analyses are in progress.

An important aspect when analyzing the life-span incidence of lung cancer after inhalation of different radionuclides is knowledge of the incidence, types, and times of occurrence of lung cancers in unexposed control dogs. The third report in this section describes results seen to date in a population of 225 life-span control dogs. As of September 30, 1992, 204 of these dogs had died or been euthanized. The observed crude incidence was 10% in female and 6% in male dogs although this gender effect was not statistically significant. The age specific incidence increased markedly after 14 yr of age and was nearly 10% in both males and females after 16 yr. All of the tumors observed were carcinomas, most of which were papillary adenocarcinomas.

Another aspect of lung cancer, tumor growth-rate patterns, is the subject of the fourth report. Radiographs were examined of 174 dogs that developed pulmonary neoplasms after inhalation of $^{238}PuO_2$ or $^{239}PuO_2$. From this group, 29 cases were selected for further analyses. Digital traces of tumor outlines on the radiographs were entered into the computer and used to determine tumor volume as a function of time. The data suggest that growth rates of Pu-induced lung tumors have doubling times between 1 and 9 mo. The dogs generally fell in one of two groups having doubling times of either 1 to 3 mo or 6 to 9 mo. Additional analyses are being conducted to determine an appropriate point in tumor development to use for dose calculations.

The last report in this section discusses analyses of survival times in dogs exposed by inhalation to $^{239}PuO_2$ repeatedly at 6-mo intervals for 10 yr. This analysis focused on death from radiation pneumonitis and pulmonary fibrosis. The average dose rate was found to be a useful way for predicting the response to multiple exposures from a single exposure.

The current status and recent progress of life-span studies from the University of Utah begin the next major section of this annual report. These studies were begun in the early 1950s for the purpose of determining the radiotoxicity of ^{239}Pu relative to that of ^{226}Ra for comparison with results obtained in humans containing burdens of ^{226}Ra. A number of studies with other radionuclides, primarily alpha emitters, were added in later years.

The specific objectives of these studies are briefly presented followed by a description of the general procedures. The main difference between the Utah studies and the ITRI studies is the exposure route. All of the Utah studies involve exposure by a single intravenous injection (or repeated injections for ^{224}Ra), whereas all the ITRI exposures, except for $^{137}CsCl$, were given by single or repeated inhalation exposures. The Utah studies involved both life-span studies and special serial-sacrifice studies. Of primary interest at the present time is completion of the life-span studies. Study-specific features are presented for studies of young-adult Beagles that received intravenous injections of 1 of 10 different radionuclides or of immature or aged Beagle dogs injected with ^{239}Pu or ^{226}Ra.

Thirty-three dogs in the University of Utah-initiated studies died or were euthanized between September 30, 1991, and September 30, 1993, leaving a total of six living dogs on study. These living dogs are in the study of ^{224}Ra in young adult dogs or ^{226}Ra in immature dogs.

Research efforts in the Utah studies fall into three general categories: 1) continued care and observation of the dogs still alive, 2) detailed dosimetric studies, at the organ and local levels, of these injected radionuclides and the factors that influence these dose patterns, and 3) completion of final reviews of biological materials and data, compilations and analyses of data, and preparation of final study reports for publication in the open, scientific literature. Care and study of the dogs on study is continuing at the ITRI facility.

Most of the scientific effort at the University of Utah is currently being directed to completion of major life-span studies and the associated dosimetry studies required to determine dose-response relationships and estimated health risks for humans. The current focus of study completion activities is directed primarily to the studies of young adults dogs injected intravenously with either ^{226}Ra or ^{239}Pu. Milestone schedules are given for the various segments of these studies that need to be completed prior to completion of overall summary manuscripts on these studies. These individual milestone activities are also leading to other manuscripts that present more detailed examinations of the various dose and effects results obtained as well as analyses that cut across two or more studies.

Seven brief reports are given as examples of efforts underway in these studies. The first of these reports examines the distribution of skeletal malignancies in dogs injected with ^{239}Pu citrate when they were

young adults. The distribution of ^{239}Pu-induced bone tumors was compared with the distribution of ^{226}Ra-induced bone tumors. The ^{226}Ra exposed dogs showed more bone tumors in the tibia, and the ^{239}Pu resulted in more tumors in the axial skeleton. Site-specific bone turnover rate and percent of red marrow at the site (vascularity) may have been important influencing factors in these distribution patterns.

The second report discusses the occurrence of metastases in dogs with skeletal malignancies. For most factors studied, no significant differences were established between dogs with and without metastases. However, larger tumor volumes at death appeared to be associated with the probability of metastasis. The fraction of dogs with metastasis increased monotonically with increasing tumor volume at death.

Skeletal malignancies in dogs injected with ^{241}Am were examined in the third report in this section. When all dosage groups >3 Gy were excluded from the analysis, a linear relationship of percent of dogs with skeletal malignancy = A = 0.76 + 30D is obtained where D is the average skeletal dose to 1 yr before death. The ratio of this equation to a similar one fitted to data for ^{226}Ra-injected dogs indicates that ^{241}Am was about six times more effective in producing bone cancers per unit of average bone dose than was ^{226}Ra.

Another report on the ^{241}Am life-span study in dogs involves thyroid lesions. Although only a relatively small fraction of the injected ^{241}Am was deposited in the thyroid, it resulted in high local concentrations because of the small mass of the thyroid. Follicular atrophy and interstitial fibrosis were seen at the higher dosage levels. However, the incidence of thyroid tumors in the Am-treated dogs was not significantly different from the incidence seen in the control dogs.

The fifth report in this section addresses data from the University of Utah studies that may pertain to the question of leukemia which may be caused by inhaled radon or thoron progeny. In the Utah studies, dogs injected with ^{226}Ra, ^{228}Ra, or ^{228}Th received chronic internal irradiation from the gaseous decay products ^{222}Rn, radon, or ^{220}Rn, thoron. Some of these gaseous progeny might escape to the marrow cavity and irradiate the red marrow. No strong effect of myeloid or lymphoid malignancy or of mast cell malignancy was observed in dogs having either radon or thoron in their body as compared with control animals or with dogs injected with other alpha-emitting radionuclides.

The sixth and seventh reports are directed to issues of skeletal dosimetry. One of these reports discusses the statistics of hits to bone cell nuclei, and the other examines static and dynamic bone histomorphometry in ^{239}Pu-treated dogs. In the statistical analysis, the probability of no hits to the nuclei of bone-lining cells was examined for first and subsequent generations of bone cells in the cases of random or deterministic remodeling. For the first generation of bone cells, age-dependent remodeling gives a higher probability of no hits than does random remodeling. On the other hand, for subsequent generations, age-dependent remodeling gives a lower probability of no hits than does a random one.

The histomorphometry report examines the possible effects of cage confinement on the early dosimetry of bone-seeking, alpha-emitting radionuclides. Some differences were observed in bone mass and architecture as well as some bone turnover rates. However, the currently available results are too limited to lead to definite conclusions.

The third section of this document provides a brief status report on the dogs moved to ITRI from ANL in January 1991. Seventy-three dogs were moved to ITRI. By the end of FY-1993, 43 of these dogs had died or were euthanized. All of the surviving dogs are being followed medically, and gross and histopathology information will be obtained at death.

The sections on the ITRI, Utah, and ANL studies are followed by two sections that provide references to open literature and document publications produced by the ITRI and Utah efforts. Specific references to open literature publications during the past fiscal year are included for both organizations.

This annual report concludes with publication of the annually revised appendix tables that list pertinent experimental information for every dog assigned to either an ITRI- or Utah-initiated study. These tables are working documents for which individual entries may change from time to time as new or revised information becomes available. When the information in a specific table reaches the point where further changes are unlikely, it will be so noted. None of the tables has yet reached that stage.

I. ITRI LIFE-SPAN STUDIES IN DOGS

A. SPECIFIC PROJECT OBJECTIVES

The major objectives of these studies are to define the late-occurring health effects of inhaled radionuclides, to determine appropriate dose-response functions for describing the occurrences of these effects, to gain an understanding of the relative importance of various dose- and effect-modifying factors, and to use these results to estimate human health risks from inhaled radionuclides. Because the information necessary to describe these relationships is not available from human exposures to radionuclides, it is necessary to perform studies in laboratory animals to address these issues.

The series of life-span studies conducted in Beagle dogs for this project were designed to determine the radiotoxicity of representative radionuclides found in the inventories of various types of nuclear reactors, defense production facilities, and associated waste products. Specific questions that are addressed in these studies are as follows:

(1) What are the organs at risk relative to the solubility of the chemical form of the radionuclides?

(2) What is the importance of total dose and dose rate to the lung with respect to beta-emitting radionuclides in producing biological effects?

(3) What is the importance of the uniformity of dose to the lung from alpha-emitting radionuclides relative to the risk of lung cancer?

(4) Does the age of the individual at the time of exposure modify dose and resulting effects?

(5) Does the protraction of dose by repeated exposures have an important effect on biological responses?

Our major focus is on life-span studies in dogs; however, studies are also being done in rodents and in nonhuman primates. The purpose of these latter studies is to provide information from other species that will strengthen and improve the extrapolation of data from laboratory animals to humans.

B. EXPERIMENTAL APPROACHES

1. General Procedures

Each dog life-span study involves dogs that were exposed at one of 4 to 10 levels plus unexposed control dogs. Typically, each exposure level contained 12 dogs, although in a few instances, a particular level contained more or less than 12 dogs. All dogs used were purebred Beagles from the Institute's colony. Before being placed on study, each dog received a complete medical evaluation to ensure its suitability for inclusion in a life-span study. Dogs were placed on study according to a randomized block design. Two or more blocks of dogs, at least one block of each sex, each containing one dog at each desired exposure level and a control dog, were entered on study at a particular time. Entry of the full complement of dogs in a given study was spread over 2 to 5 yr.

With the exception of the study in which $^{137}CsCl$ was administered by intravenous injection, all radionuclides were administered by single or repeated, brief, per-nasal inhalation exposure. Dogs were whole-body counted immediately after exposure and periodically thereafter, to quantitate the initial body burden of the inhaled radionuclide and its subsequent retention. Urinary and fecal excretions were collected daily in the early post-exposure period and periodically thereafter, as another means of quantifying radionuclide retention.

All dogs on study received annual medical evaluations, as well as clinical treatment when required. The serial blood cell counts and serum chemistry determinations and the radiographic information were compiled into individual, lifetime medical records for each dog. At death, each dog received a complete necropsy, with gross examination of tissues and organs and collections of specimens for histopathology and radioanalysis of radionuclide content. Tissue specimens were examined histopathologically, and a case summary and diagnoses were prepared. Additional dosimetry data were obtained from the serial sacrifice of dogs exposed in parallel studies using the same radionuclides and aerosol forms as in the life-span studies. Histopathology results are encoded according to SNODOG, a modified version of the SNOMED nomenclature system, and entered into a FOCUS database along with major clinical results for each dog.

2. Study-Specific Features

a. Beta-Emitting Radionuclides Inhaled in a Relatively Soluble Form

The solubility of inhaled material in body fluids has a definite effect on the translocation of radionuclides from the lung and influences which organs receive significant radiation doses. The four radionuclide compounds chosen for these studies, $^{90}SrCl_2$, $^{144}CeCl_3$, $^{91}YCl_3$ and $^{137}CsCl$, provided a range of organs at risk, including lung, liver, skeleton, and whole body. For the purposes of this report, use of the terms ^{90}Sr, ^{137}Cs, or ^{144}Ce refers to an equilibrium mixture of ^{90}Sr-^{90}Y, ^{137}Cs-^{137m}Ba, or ^{144}Ce-^{144}Pr, respectively. Specific features of these four studies are given below.

i. $^{90}SrCl_2$ (Inhalation exposures performed from 1965-1967)

This study involves 48 dogs that received single inhalation exposures to graded levels of ^{90}Sr and 15 control dogs. The exposure aerosol was $^{90}SrCl_2$ in a nonradioactive CsCl vector. The long-term retained burdens ranged from 0.37 to 4.44 MBq/kg body weight. Because ^{90}Sr is a bone-seeking radionuclide, the skeleton was the main target organ.

ii. $^{144}CeCl_3$ (Inhalation exposures performed from 1966-1967)

This study involves 55 dogs that received single inhalation exposures to $^{144}CeCl_3$ on a CsCl vector and 17 control dogs. The long-term retained burdens ranged from 0.096 to 13.3 MBq/kg body weight. The main target organs were lung, liver, skeleton, and nasal cavity.

iii. $^{91}YCl_3$ (Inhalation exposures performed from 1966-1967)

This study involves 42 dogs that received single inhalation exposures to $^{91}YCl_3$ on a CsCl vector and 12 control dogs. The long-term retained burdens ranged from 0.52 to 20 MBq/kg body weight. The main target organs were similar to those for ^{144}Ce - lung, liver, skeleton, and nasal cavity.

iv. $^{137}CsCl$ (Intravenous injections were done in 1968-1969)

This study involves 54 dogs that received a single intravenous injection of $^{137}CsCl$ and 12 control dogs. The initial body burdens of ^{137}Cs in the injected dogs ranged from 32.5 to 148 MBq/kg body weight. Because of the soluble nature of the injected material and the fact that the distribution of cesium follows that of potassium in the body, the resulting pattern of irradiation was generally a whole-body exposure, in contrast to the three studies listed above where the radionuclides were preferentially deposited in only a few organs.

b. Beta-Emitting Radionuclides Inhaled in a Relatively Insoluble Form

This series of four studies was designed to investigate the carcinogenic response of the lung to similar doses of chronic beta radiation delivered over different periods of time. To achieve this objective, four radionuclides, with radioactive half-lives ranging from 64 h to 29 yr and each encapsulated in a common form of vector aerosol, fused aluminosilicate particles (FAP), were studied. Specific features of these four studies are given below.

i. ^{90}Y in FAP (Inhalation exposures performed from 1969-1971)

This study involves 89 dogs that received single inhalation exposures to ^{90}Y-FAP and 12 control dogs. The initial lung burdens (ILBs) ranged from 2.96 to 192 MBq/kg body weight. Because the half-life of ^{90}Y is relatively short, 2.6 days, and ^{90}Y in this form is relatively insoluble, the major radiation dose was delivered to the lung.

ii. ^{91}Y in FAP (Inhalation exposures performed from 1970-1971)

This study involves 96 dogs exposed once to graded levels of ^{91}Y-FAP and 12 control dogs. ILBs ranged from 0.407 to 13.3 MBq/kg body weight. The effective half-life of ^{91}Y is approximately 53 days in the lung. The main target organs were the lung and tracheobronchial lymph nodes.

iii. ^{144}Ce in FAP (Inhalation exposures performed from 1967-1971)

This study involves 111 dogs that received single brief exposures to ^{144}Ce-FAP as young adults and 15 control dogs. ILBs ranged from 0.00009 to 7.77 MBq/kg. The effective half-life of ^{144}Ce in the lung is about 180 days. Lung and tracheobronchial lymph nodes were the main target organs.

iv. ^{90}Sr in FAP (Inhalation exposures performed from 1970-1974)

This study involves 106 dogs that received single brief exposures to ^{90}Sr-FAP as young adults and 18 control dogs. ILBs ranged from 0.0044 to 3.55 MBq/kg body weight. The radioactive half-life of ^{90}Sr, about 29 yr, is the longest of the four radionuclides used in this series. When incorporated in FAP, the effective pulmonary retention half-life is about 500 days. The main target organs were lung and tracheobronchial lymph nodes.

Figures 1 and 2 illustrate the effect of different retention patterns in the lung for the four studies in which young adult dogs inhaled radionuclides in FAP aerosols These differences result from effective half-lives in lung that range from ~2 days for ^{90}Y to more than 500 days for ^{90}Sr. In Figure 1, the expected change in radiation dose rate as a function of time is shown for the levels of exposure selected to produce initial dose rates of 1 Gy/day. The dose patterns in Figure 1 required assignment of similar activity levels for ILBs, because the beta energies are similar for the four radionuclides. For the same ILB, different dose-rate patterns result in marked differences in the long-term cumulative radiation dose to the lung. Differences in radiation dose patterns among the different radionuclides are demonstrated in Figure 2, where cumulative dose curves resulting in infinite

doses of 20 Gy to the lung required IIE ranging from 48 MBq for ^{90}Y (initial dose rate = 5.3 Gy/day) to 0.26 MBq for ^{90}Sr (initial dose rate = 0.57 Gy/day). Table 1 shows the various organs that received substantial beta radiation doses in these studies and thus, were especially at risk for the development of long-term biological effects.

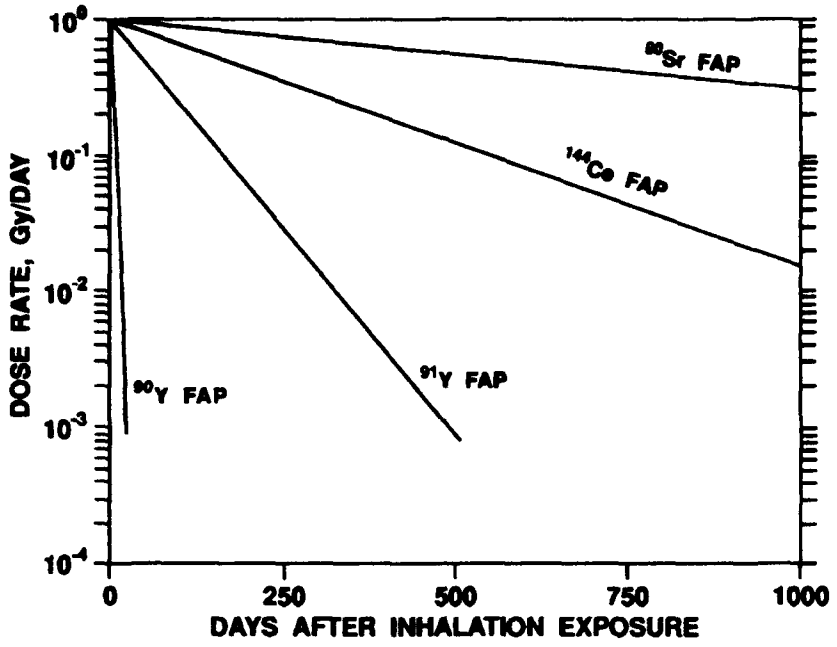


Figure 1. Calculated absorbed beta dose rate to the lung for Beagle dogs for various inhaled radionuclides 0normalized to 1 Gy/day initial dose rate (110 g lung). FAP = fused aluminosilicate particles.

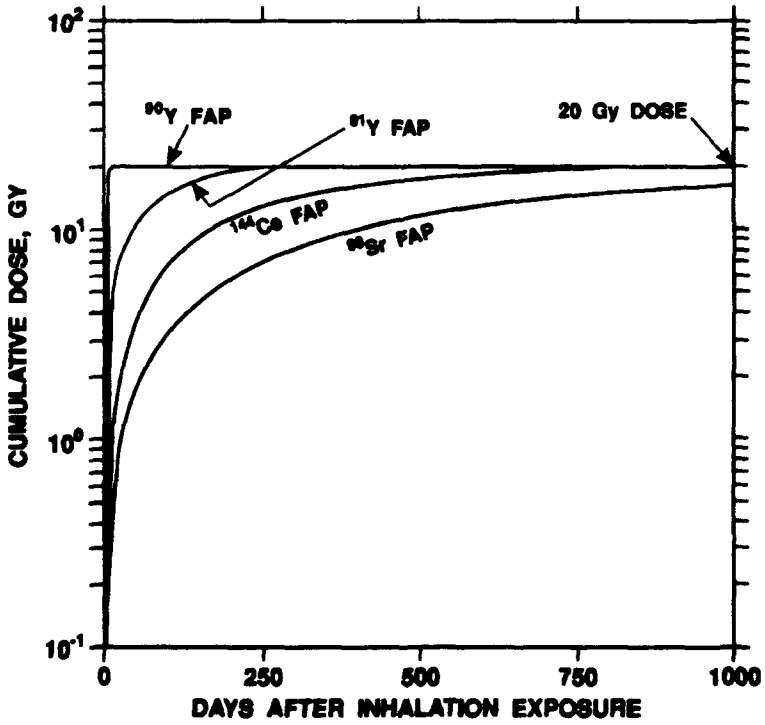


Figure 2. Calculated patterns for accumulating total beta-dose to the lung in Beagle dogs of 20 Gy from various inhaled radionuclides (110 g lung). FAP = fused aluminosilicate particles.

Table 1

Life-Span Dose-Response Studies in Beagle Dogs that Received Single, Brief Exposures by Inhalation To Beta-Emitting Radionuclides

Aerosol and Form[a]	Whole-Body Effective Retention Half-Life	Age at Inhalation Exposure	Organs Receiving Substantial Radiation Doses				
			Lung	Skeleton	Liver	Whole Body	TBLN[b]
$^{137}CsCl$	30 days	13 months				++[c]	
$^{91}YCl_3$	59 days	13 months	++	++	++		
$^{144}CeCl_3$	284 days	13 months	++	++	+++		
$^{90}SrCl_2$	5-10 years	13 months		+++			
^{90}Y FAP[d]	2.5 days	13 months	++				+
^{91}Y FAP	53 days	13 months	+++				++
^{144}Ce FAP	> 200 days	13 months	+++	+	+		
^{90}Sr FAP	> 500 days	13 months	+++	+	+		
^{144}Ce FAP	> 200 days	3 months	+++	+	+		+++
^{144}Ce FAP	> 200 days	8-10 years	+++	+	+		+++

[a]All polydisperse aerosols, except $^{137}CsCl$ which was given by intravenous injection.
[b]Tracheobronchial lymph nodes.
[c]Relative magnitude of dose received.
[d]Fused aluminosilicate particles.

c. Uniformity of Pulmonary Irradiation from an Inhaled Alpha-Emitting Radionuclide

To address the question of whether a nonuniform distribution of alpha radiation in the lung is more carcinogenic than a uniform distribution, five life-span studies are being conducted using Beagle dogs that inhaled either $^{238}PuO_2$ or $^{239}PuO_2$ particles of different monodisperse sizes. A schematic representation of the experimental design for these studies is shown in Figure 3, where each cube represents one dog. Five different aerosols have been used, each resulting in particles with different levels of alpha-emitter radioactivity. For each aerosol, a randomized block design was used for entering dogs on study, similar to that used for the beta-gamma dose-response studies.

Twelve blocks of dogs were exposed to each aerosol to achieve graded ILBs ranging from 0.37-21 kBq Pu/kg body weight. Sixty control dogs were included, 12 for each aerosol. Two additional ILB levels of 93 and 8.5 Bq Pu/kg body weight were included for the studies in which young-adult dogs and immature dogs inhaled $^{239}PuO_2$ aerosols of 1.5 μm activity median aerodynamic diameter (AMAD). An ILB of ^{239}Pu of 8.5 Bq Pu/kg body weight in a Beagle dog is equivalent to a lung burden of 590 kBq Pu in a 70-kg human.

The information given in Figure 3 and in Table 2 was used to calculate the initial dose rate averaged over the total lung and the local dose rate around each particle, for each particle size and activity level shown in Figure 4. With two different radioisotopes of plutonium and three different particle sizes, the alpha activity per particle and the corresponding, idealized local dose rate to a sphere of lung tissue with a radius of 180 μm (density = 0.22 g/cm^3) surrounding an individual particle varied by a factor of ~40,000. Also, the use of six activity levels for each aerosol resulted in a difference of about a factor of 50 in the initial dose rate, averaged over the entire lung. Thus, these five experiments permit comparison of the relative influences of both local dose rates and average dose rates in producing long-term biological effects. The average dose rate to the lung

will decrease with time after exposure, as plutonium is cleared from the lung. The local dose rate can either increase or decrease as a result of particle movement, aggregation, dissolution, or particle breakup in the lung.

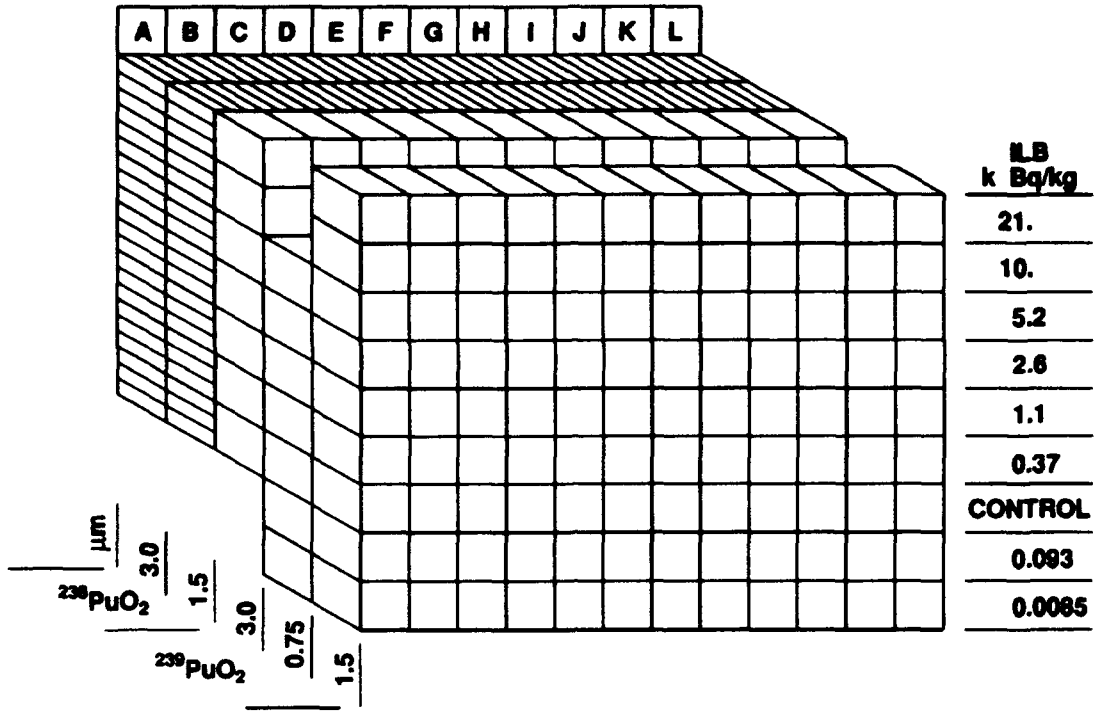


Figure 3. Schematic representation of the experimental design for life-span studies involving young adult dogs exposed to different monodisperse aerosols of ^{238}Pu (90%)PuO_2 or $^{239}PuO_2$. Each cube represents one dog entered into the experiment at 12-14 mo of age.

Table 2

Some Characteristics of Aerosol Particles Containing Pure Transuranic, Alpha-Emitting Radionuclides

Aerosol	Specific Activity (GBq/g)	Activity (Bq) per Particle[a,b] AMAD[c] = 0.75 μm RD[d] = 0.18 μm	AMAD = 1.5 μm RD = 0.44 μm	AMAD = 3.0 μm RD = 0.96 μm
$^{239}PuO_2$	2.0	0.000049	0.00074	0.0074
$^{241}AmO_2$	110	0.0027	0.039	0.41
$^{238}PuO_2$	560	0.014	0.20	2.1
$^{244}CmO_x$	2,700	0.066	0.96	10
$^{242}CmO_x$	110,000	2.7	39	410

[a]Density of 8 was used for these calculations. This is the measured density for $^{238}PuO_2$ and $^{241}AmO_2$ particles produced by standard methods at this Institute.

[b]The ^{238}Pu used at this Institute contained 10% ^{239}Pu by weight. This produced a specific activity of 510 GBq/g and particle activities of 0.013, 0.18, and 1.9 Bq, respectively, for 0.75-μm, 1.5-μm, and 3.0-μm AMAD particles.

[c]AMAD=Activity median aerodynamic diameter of monodisperse particles (geometric standard deviation < 1.2).

[d]RD=Real or geometric diameter of the particle.

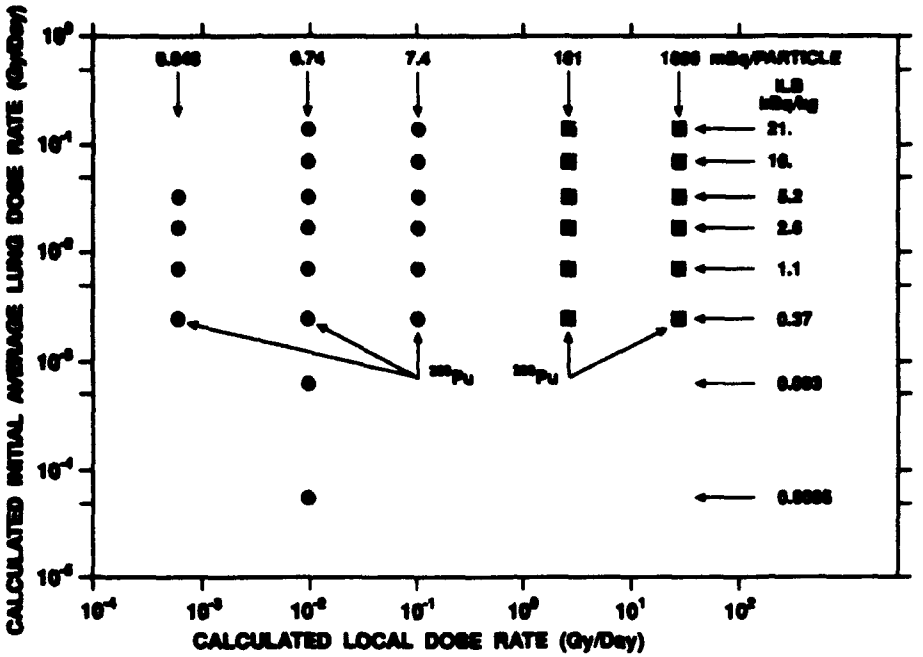


Figure 4. Calculated dose relationships for the five life-span studies involving dogs that inhaled monodisperse aerosols of ^{238}(90%)PuO_2 or $^{239}PuO_2$. Local dose rate was computed in a sphere of lung tissue (density = 0.22 g/cm^3) having a radius of 180 μm. The calculation of average dose rate was based on a 110-g lung. Self-absorption of alpha energy by the particles was negligible.

Inherent in the experimental design is a difference in the number of particles associated with a given ILB level for each aerosol. The fraction of the lung irradiated can be estimated by assuming a spherical irradiation volume of 2.4 x 10^7 μm^3 around each particle, and by determining how many of these volumes are present in the volume of a 110-g lung. Results of such a theoretical calculation are presented in Figure 5. When the number of these irradiation volumes exceeds 2.1 x 10^7, the calculated fraction of lung irradiated exceeds 1.0. For values > 1.0, some or all portions of the lung would be irradiated by the alpha emissions from more than one particle of plutonium, even if the particles are assumed to be uniformly distributed in the lung tissue, and geometrical considerations are ignored. Our experimental evidence suggests that inhaled particles are not uniformly distributed, but are randomly deposited in the lung. This random distribution indicates that theoretical calculations of the fraction of lung irradiated are slight overestimates. All of the ILB levels for the exposures to 0.75 μm AMAD particles of $^{239}PuO_2$ and for the upper four levels for the exposures to 1.5 μm AMAD particles of $^{239}PuO_2$ gave calculated fractional irradiations > 1.0. The remaining $^{239}PuO_2$ ILB levels and all of the $^{238}PuO_2$ exposure levels resulted in calculated values < 1.0 for fractions of lung irradiated. Because of the overlap in fractions of lung irradiated for the several different sizes of aerosols, the effects of local dose rate are being studied, while the fraction of lung irradiated is held constant. To obtain more detailed dosimetric information, parallel studies have been conducted in dogs and rodents exposed to $^{239}PuO_2$ and $^{238}PuO_2$ aerosols and serially sacrificed at selected times after exposure. These studies have provided valuable data on the organ and tissue distribution of plutonium with time after exposure.

The dogs in the originally planned five studies of different-sized aerosol particles of $^{239}PuO_2$ and $^{238}PuO_2$ have all been exposed and entered into these studies. After the exposures were completed, we found that the $^{238}PuO_2$ particles began to break up in the lung at about 100 days after exposure. This resulted in increased solubility and translocation of ^{238}Pu to bone and liver. Although some $^{238}PuO_2$ remained in the lung, the dose patterns to lung, liver, and bone were altered from what was initially expected to occur. The $^{239}PuO_2$ particles did not undergo any observable breakup, presumably because of their lower specific activity. Although this unexpected early dissolution of the $^{238}PuO_2$ particles changed the experimental design of the original study, important information is being obtained on the toxicity of inhaled $^{238}PuO_2$. At the same time, the $^{239}PuO_2$-exposed dogs are providing information relative to the original hypothesis.

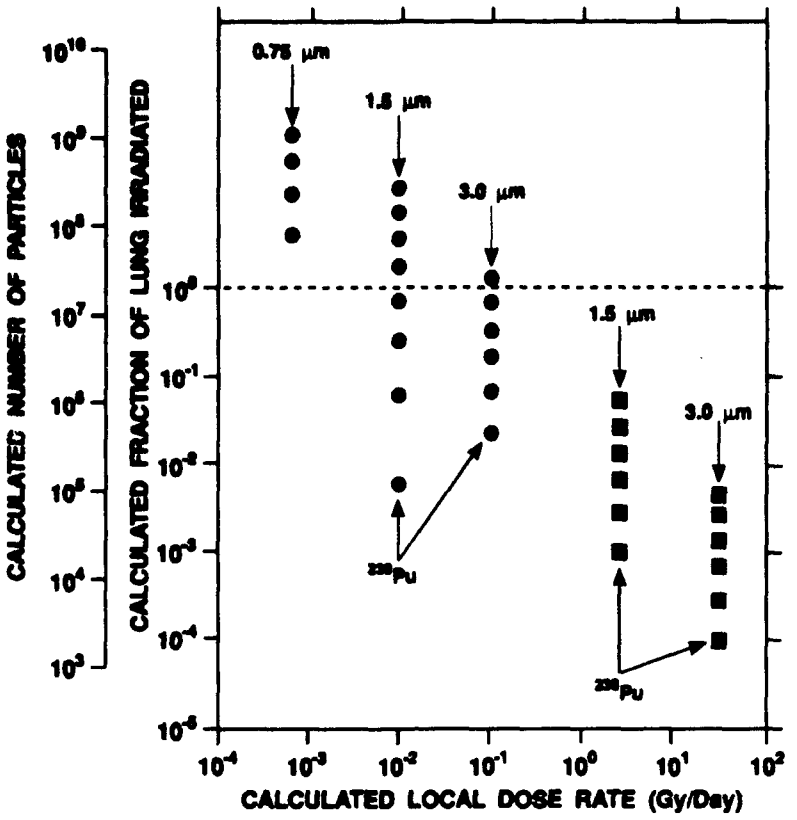


Figure 5. Calculated numbers of particles and fractions of lung irradiated based on the sphere of irradiation associated with each particle (2.4×10^7 μm^3) and a determination of how many of these volumes could be contained in the lung before overlapping occurred. Self-absorption of alpha energy by the particles is negligible.

Specific details on these studies are given below.

i. $^{238}PuO_2$ (Inhalation exposures performed from 1973-1976)

Two studies were initiated with young-adult dogs exposed once, briefly, to monodisperse particles of $^{238}PuO_2$. These two studies used particles with aerodynamic diameters of 1.5 and 3.0 μm, respectively. Each study was comprised of 72 ^{238}Pu-exposed dogs and 12 control dogs. The ILBs ranged from 0.11 to 37 kBq/kg body weight in the 1.5 μm study and 0.37 to 55.5 kBq/kg body weight in the 3.0 μm study. Although the particles of $^{238}PuO_2$ were initially quite insoluble, these particles fractured after several months in the body, leading to decreased particle sizes and increased dissolution. Subsequent absorption of ^{238}Pu into the systemic circulation, with translocation to other organs, resulted in the skeleton and liver becoming target organs, as well as the lung.

ii. $^{239}PuO_2$ (Inhalation exposures performed from 1977-1979)

Three studies were initiated in which young-adult dogs were exposed once, briefly, to monodisperse particles. There were 48 dogs that inhaled 0.75 μm particles of $^{239}PuO_2$, 96 dogs that inhaled 1.5 μm particles of $^{239}PuO_2$, and 72 dogs that inhaled 3.0 μm particles of $^{239}PuO_2$. Each study had 12 control dogs. The ILBs ranged from 0.26 to 7.4, from 0.03 to 37, and from 0.22 to 74 kBq/kg body weight for the 0.75 μm, 1.0 μm, and 3.0 μm studies, respectively. Because the inhaled $^{239}PuO_2$ remained in a very insoluble form in the body, the lungs were the main target organs in these studies.

d. Effects of Age

To examine the possible effects of age on the dose-response relationships for both a beta- and an alpha-emitting radionuclide inhaled in a relatively insoluble form, additional life-span studies were conducted with dogs that were either 3 mo or 8 to 10.5 yr old at the time of inhalation exposure. The two exposure aerosols used, ^{144}Ce-FAP and $^{239}PuO_2$, will facilitate comparisons of results obtained with beta- and alpha-emitting radionuclides with results obtained from the companion, young-adult studies listed above for the same forms.

i. ^{144}Ce in FAP in immature dogs (Inhalation exposures performed from 1972-1976)

This study involved 49 dogs that were exposed once, briefly, to ^{144}Ce-FAP aerosols at 90 days of age and five control dogs. The ILB of ^{144}Ce ranged from 0.15 to 5,180 kBq/kg body weight. The lung and tracheobronchial lymph nodes were the main target organs.

ii. ^{144}Ce in FAP in aged dogs (Inhalation exposures performed from 1972-1975)

This study involves 42 dogs that inhaled graded activity levels of ^{144}Ce-FAP when they were 8 to 10.5 yr old and 12 control dogs. ILBs in these 42 dogs ranged from 88.8 to 2,780 kBq/kg body weight. The main target organs were lung and tracheobronchial lymph nodes.

iii. $^{239}PuO_2$ in immature dogs (Inhalation exposures performed from 1979-1982)

This study involves 96 dogs that inhaled graded activity levels of a 1.5 μm monodisperse aerosol of $^{239}PuO_2$ when they were 90 days old and 12 control dogs. The ILBs ranged from 0.01 to 29 kBq/kg body weight. Lung and tracheobronchial lymph nodes were the primary target organs.

iv. $^{239}PuO_2$ in aged dogs (Inhalation exposures performed from 1979-1982)

This study involves 48 dogs that inhaled 1.5 μm particles of $^{239}PuO_2$ when they were 8 to 10.5 yr old and 12 control dogs. The ILBs ranged from 0.48 to 24 kBq/kg body weight. Lung and tracheobronchial lymph nodes were the main target organs.

e. Effects of Protracted Exposure

Two studies were conducted to study dose protraction, one with a beta emitter, ^{144}Ce, and one with an alpha emitter, ^{239}Pu.

i. ^{144}Ce in FAP repeated exposures (Inhalation exposures performed from 1973-1975)

This study involves 27 dogs that received a brief inhalation exposure to ^{144}Ce-FAP every 8 wk for 13 exposures, and nine control dogs. The 27 exposed dogs were divided into three groups of nine dogs, whose lung burdens of ^{144}Ce were (1) increased by 92 kBq/kg with each exposure, (2) re-established at 333 kBq/kg, or (3) re-established at 165 kBq/kg body weight. In each case, lung and tracheobronchial lymph nodes were the main target organs.

ii. $^{239}PuO_2$ repeated exposures (Inhalation exposures performed from 1977-1988)

This study involves 36 dogs that received a brief inhalation exposure to $^{239}PuO_2$ every 6 mo for 20 exposures. These 36 dogs were divided into two groups, for which the exposure goals and numbers of dogs were (1) lung burden increased 3.7 kBq every 6 mo (12 dogs) and (2) lung burden increased 0.37 kBq every 6 mo (24 dogs). Another group of 24 dogs received an ILB of about 3.7 kBq in one brief inhalation exposure. Twelve dogs served as controls. The singly exposed dogs and the controls were sham exposed 19 times. Lung and tracheobronchial lymph nodes were the target organs.

3. Additional Approaches Being Used in the Life-Span Studies

Additional approaches to acquiring biological information related to the pathogenesis of alpha radiation-induced lung disease have been implemented in animals in the ongoing studies. Spontaneous Beagle dog lung tumors selected from dogs exposed to $^{239}PuO_2$ through inhalation were examined for altered expression of erbB2 ($p185^{erbB2}$) protooncogene product, and mutations in both the K-ras protooncogene and the p53 tumor suppressor gene. Altered expression of $p185^{erbB2}$ and p53 protein was determined by immunohistochemical analysis of 117 tumors representing different histotypes in both exposed (n = 80) and unexposed (n = 37) animals. Twenty-eight tumors were analyzed for specific K-ras mutations by PCR amplification and direct sequencing. Fourteen percent (14%) (16/116) of all lung neoplasms showed elevated nuclear accumulation of p53 protein. Adenosquamous and squamous cell histotypes were the most frequently perturbed regardless of exposure history and comprised 94% of all tumors with p53 dysfunction. Eighteen percent (21/117) of all tumors had evidence of $p185^{erbB2}$ overexpression. Intrapulmonary metastasis from primary tumors overexpressing $p185^{erbB2}$ also showed evidence of erbB2 gene dysfunction. No differences in $p185^{erbB2}$ expression were noted between spontaneous and plutonium-induced lung tumors, nor was there a relationship between total $^{239}PuO_2$ lung dose (Gy) at death and altered $p185^{erbB2}$ or p53 protein expression. K-ras mutations were not detected in codons 12, 13, or 61 of unexposed (n = 9) or plutonium-induced lung tumors (n = 19). These data indicate that p53 and especially K-ras gene dysfunction as a result of missense mutation are infrequent events in both spontaneous and $^{239}PuO_2$-induced lung neoplasia of laboratory raised Beagle dogs and suggest that alternative mechanisms of gene alteration are involved in canine pulmonary carcinogenesis.

C. CURRENT STATUS OF ITRI STUDIES

1. General Overview

The current status of the 19 dog longevity studies at ITRI is presented in Table 3. Overall, about 3% of the total population of study dogs remained alive on September 30, 1993. At the beginning of this 2-yr report period, 13 of these 19 studies had reached the point at which all dogs were dead, and two other studies reached this same point during the report period. Current research efforts are directed at three main foci: (1) continuation of the care and study of dogs still alive in four of these studies, (2) collection and preservation of biological specimens obtained at necropsy for future efforts to develop early biological indicators of lung tumor production, and (3) completion of final reviews of biological specimens and the associated dosimetry data, compilation and analysis of data, and preparation of final study reports for publication in the open scientific literature. When a study is fully completed and submitted for publication, the study materials (slides, tissue blocks, etc.) records, and computer files will be transferred to the National Radiobiology Archive (NRA) at Richland, WA.

The brief reports that follow in Section I.C.2. give the current status of each longevity study in which dogs remain alive. This section is followed by a compilation of pertinent references to previous annual reports for all 11 studies in which all dogs are now dead (Section I.C.3.). These status reports are followed by a series of progress reports that present current highlights related to the three main foci.

Table 3

Current Status of Life-Span Radionuclide Toxicology Studies in Beagle Dogs at the Inhalation Toxicology Research Institute
(9/30/93)

Age at Inhalation	Radionuclide and Form	Inhalation Exposure Year	Dogs Entered in Study	Number Alive		
				9/30/91	9/30/92	9/30/93
12-14 mo (young adult)	$^{90}SrCl_2$	1965-1967	63	0	0	0
	$^{144}CeCl_3$	1966-1967	72	0	0	0
	$^{91}YCl_3$	1966-1967	44	0	0	0
	$^{137}CsCl$	1968-1969	66	0	0	0
	^{90}YFAP	1969-1971	101	0	0	0
	^{91}YFAP	1970-1971	108	0	0	0
	^{144}CeFAP	1967-1971	126	0	0	0
	^{90}SrFAP	1970-1974	124	0	0	0
	$^{238}PuO_2$ (1.5)	1974-1976	84	0	0	0
	$^{238}PuO_2$ (3.0)	1973-1976	84	0	0	0
	$^{239}PuO_2$ (0.75)	1977-1979	60	4	2	1
	$^{239}PuO_2$ (1.5)	1977-1979	108	21	10	4
	$^{239}PuO_2$ (3.0)	1977-1979	84	8	4	0
3 mo (immature)	^{144}CeFAP	1972-1976	54	1	0	0
	$^{239}PuO_2$	1979-1982	108	66	55	43
8-10.5 yr (aged)	^{144}CeFAP	1972-1975	54	0	0	0
	$^{239}PuO_2$	1979-1982	60	0	0	0
Began at 12-14 mo	^{144}CeFAP Repeated	1973-1975	36	0	0	0
	$^{239}PuO_2$ Repeated	1977-1988	72	6	4	1
		Total	1508	106	75	49

2. Summary Reports for Studies with Living Dogs

a. Toxicity of Inhaled $^{239}PuO_2$ in Beagle Dogs. XIV:

i. Monodisperse 0.75 μm AMAD Particles.

ii. Monodisperse 1.5 μm AMAD Particles.

iii. Monodisperse 3.0 μm AMAD Particles.

Study Contact: F. F. Hahn

Studies of the long-term biological effects of ^{239}Pu are being conducted because ^{239}Pu is a major radionuclide in most nuclear fuel cycles and in the production of nuclear weapons. These studies also directly investigate the importance of uniform vs. nonuniform alpha irradiation of the lung. Young-adult dogs of both sexes inhaled one of three sizes of monodisperse aerosols of $^{239}PuO_2$; 0.75, 1.5, or 3.0 μm AMAD. Forty-eight dogs were exposed to 0.75 μm AMAD particles; 96 were exposed to 1.5 μm AMAD particles; 72 were exposed to 3.0 μm AMAD particles; and 36 dogs were exposed only to the aerosol vehicle. The initial pulmonary burdens ranged from 0.03 to 74 kBq/kg body mass. To assess the plutonium activity initially deposited in the lung, a short-lived, gamma-emitting radionuclide, ^{169}Yb, was incorporated into the PuO_2 aerosol, and whole-body counts were performed up to 120 days after exposure. A description of the ^{169}Yb counting technique for estimating initial pulmonary burdens of plutonium was reported previously (1979-80 Annual Report, LMF-84, pp. 132-140). The methods used to prepare the monodisperse aerosols and the aerosol exposure procedures were described in the 1976-77 Annual Report, LF-58, pp. 135-138. The experimental design charts in Figures 6-8 show the present status of these studies. The dogs in these studies are being maintained to study the biological effects that may occur throughout their lives. The procedures for health evaluations of these animals have been described (1978-79 Annual Report, LF-69, pp. 134-140).

DESIGN KBQ/KG	A	B	C	D	E	F	G	H	I	J	K	L	MEAN KBQ/KG
5.2	983E 27. 2.3 E-2176	980T 34. 3.6 E-1579	992B 63. 5.9 D-1035	996U 19. 2.7 E-2446	1006B 25. 2.9 E-1961	1027U 56. 5.6 E-2779	1097E 32. 3.7 E-2281	1092S 56. 5.9 E-1371	1109B 70. 6.7 D-1520	1125S 44. 5.6 E-1280	1134C 67. 7.4 E-891	1142V 63. 7.0 E-1181	4.8
2.6	983F 17. 1.5 E-3302	982T 7.8 0.78 D-3768	990C 19. 2.0 D-2007	999S 19. 2.3 D-2886	1005C 24. 2.3 D-2085	1028U 32. 3.7 E-2742	1098C 23. 2.7 E-2031	1096S 14. 1.6 E-3115	1107A 44. 3.7 E-1757	1122T 32. 4.1 E-1525	1136A 67. 6.3 D-1467	1145T 18. 1.8 E-2563	2.7
1.1	9700 10. 0.96 E-3897	976T 7.4 0.70 D-4526	990A 17. 1.7 E-1718	1001T 23. 2.2 E-2081	1006A 14. 1.7 D-3370	1023W 19. 2.0 D-2741	1097C 14. 1.5 E-2343	1096U 7.4 0.89 E-3661	1100B 10. 1.0 E-3429	1121S 12. 1.4 E-2752	1130B 20. 1.9 E-3093	1143T 14. 1.6 D-2951	1.5
0.37	989A 6.5 0.85 E-4162	977S 4.8 0.67 E-4618	988C 3.3 0.37 E-3626	996T 2.6 0.30 E-4275	1005D 5.2 0.55 E-4171	1026S 3.3 0.37 D-4157	1096A 2.6 0.22 D-4488	1094T 4.1 0.37 D-3589	1111B 7.4 0.78 E-3375	1125T 6.3 0.78 D-3461	1134B 15. 1.5 E-3094	1143S 5.6 0.52 E-3970	0.59
CONTROL	981A 0 0 D-4977	980S 0 0 D-3609	992A 0 0 A-6037	999U 0 0 D-3006	1007C 0 0 D-1893	1022W 0 0 E-4611	1098A 0 0 E-4024	1095T 0 0 D-5552	1106A 0 0 E-4899	1121T 0 0 D-3349	1131D 0 0 E-4375	1146S 0 0 E-4705	0
	983E 27. 2.3 E-2176	=ANIMAL NUMBER =INITIAL LUNG BURDEN (KBQ) =INITIAL LUNG BURDEN (KBQ/KG) =D=DEAD, E=EUTHANIZED, A=ALIVE - DAYS AFTER EXPOSURE AT DEATH OR ON 9-30-93											

Figure 6. Experimental design for dog study with 0.75 μm AMAD monodisperse particles of $^{239}PuO_2$ (Status as of 9-30-93).

DESIGN KBQ/KG	A	B	C	D	E	F	G	H	I	J	K	L	MEAN KBQ/KG
21	972A 210. 21. E-561	9848 280 31. D-336	986A 190. 18. E-583	980U 250. 28. D-487	10158 150. 17. D-389	1023X 83. 11. E-882	1007B 200. 21. E-278	1110U 250. 37. D-206	1117B 280. 29. D-221	1137S 340. 34. D-249	1134D 74 7.0 E-192	1135S 300. 37. D-210	24
10	977B 130. 11. D-503	984T 48. 6.3 E-1377	985C 150. 15. D-1333	9845 100. 11. D-728	1027A 180. 17. D-652	1009T 63. 5.9 E-1930	1008C 140. 14. D-804	1101S 320. 32. E-347	1098B 170. 18. E-387	1141U 81. 12. D-793	1130A 41. 3.7 D-973	1159T 130. 19. E-522	14
5.2	976A 67. 5.2 D-1438	9856 63. 6.3 E-1981	987C 89. 8.5 D-1266	9897 48. 7.0 D-1884	1023B 56. 5.6 D-1787	1020T 48. 5.2 D-1134	1008B 110. 11. E-737	1098V 78. 8.9 E-947	1110B 130. 16. D-412	1141S 70. 7.0 D-345	1129A 23. 2.6 E-3052	1148U 48. 7.0 E-1540	7.4
2.6	970A 56. 5.6 D-1809	9867 37. 3.6 D-1802	988A 44. 4.4 E-2666	984T 41. 4.8 D-2013	1007A 25. 2.6 E-1941	1008S 41. 4.1 E-2269	1084B 12. 1.0 E-1647	1098S 70. 7.0 D-3204	1120A 37. 4.1 E-1713	1139U 32. 3.6 E-1785	1132C 27. 2.4 D-705	1160T 41. 4.8 E-1528	4.1
1.1	9788 8.9 1.0 E-4019	972S 14. 1.7 D-2148	998A 15. 1.9 E-4268	982T 11. 1.6 E-3068	1026D 16. 1.4 E-2414	1022T 16. 1.7 E-3535	1008D 8.1 0.78 E-2340	1099T 58. 7.0 A-5546	1098C 23. 2.2 D-1735	1130T 32. 3.7 E-1779	1128B 22. 2.1 D-882	1153T 17. 2.1 E-3366	2.3
0.37	970F 5.6 0.63 D-3945	988U 5.6 0.55 E-3633	9920 6.7 0.63 D-2315	9885 3.2 0.41 D-3783	1007B 15. 1.3 E-3778	1010T 5.2 0.52 D-1109	1082C 4.1 0.41 E-3835	1112N 34. 4.1 E-1086	1113A 9.3 0.96 E-4229	1134S 5.9 0.74 D-4732	1130C 16. 1.8 E-3833	1153S 4.1 0.44 E-4845	1.0
0.093	9720 1.3 0.15 D-5309	980U 3.4 0.37 E-4412	9948 2.3 0.23 D-5732	988U 2.3 0.26 E-5483	1017A 7.8 0.85 E-4850	1010W 1.7 0.16 A-5945	1097A 2.0 0.23 E-4843	1110S 13. 1.5 D-2380	1110A 3.0 0.35 E-4290	1146T 4.8 0.55 D-5023	1132D 2.1 0.22 A-5433	1154S 1.1 0.13 D-5016	0.41
0.0085	971C 0.74 0.088 E-5544	970S 2.7 0.28 E-4530	987A 0.70 0.067 E-4901	988S 0.78 0.081 D-3955	1014C 4.4 0.52 E-4705	1022V 0.25 0.027 D-4988	1095A 0.55 0.048 E-4516	1112U 5.6 0.58 E-5057	1100A 2.2 0.23 D-4841	1130S 1.2 0.15 D-4430	1131B 0.92 0.085 D-5203	1149T 0.92 0.12 D-4790	0.21
CONTROL	977A 0 0 E-4342	980T 0 0 E-5428	998A 0 0 E-5595	9825 0 0 E-4503	1010A 0 0 E-5216	1021S 0 0 E-5270	1093B 0 0 D-4441	1107S 0 0 E-5235	1109A 0 0 A-5537	1138S 0 0 E-4793	1131A 0 0 E-3472	1152S 0 0 E-5252	0
	972A 210. 21. E-561	=ANIMAL NUMBER =INITIAL LUNG BURDEN (KBQ) =INITIAL LUNG BURDEN (KBQ/KG) =D=DEAD, E=EUTHANIZED, A=ALIVE - DAYS AFTER EXPOSURE AT DEATH OR ON 9-30-93											

Figure 7. Experimental design for dog study with 1.5 μm AMAD monodisperse particles of $^{239}PuO_2$ (Status as of 9-30-93).

DESIGN KBQ/KG	A	B	C	D	E	F	G	H	I	J	K	L	MEAN KBQ/KG
21	984A 140. 14. E-702	981T 480. 41. D-256	984A 570. 52. D-116	1004S 420. 46. D-230	997D 240. 28. D-554	1034S 160. 21. D-506	1069A 590. 52. D-268	1101U 210. 20. E-727	1100D 270. 25. D-471	1138T 220. 33. E-631	11228 620. 74. E-105	1152V 440. 44. E-427	37
10	983A 52. 4.4 D-1636	977T 150. 19. E-589	980A 200. 19. D-686	1007S 93. 12. D-781	1001A 270. 26. E-636	1029S 110. 10. D-733	1069B 240. 21. D-754	1105T 130. 13. E-1015	1099A 230. 21. E-1098	1137U 140. 13. E-1005	1117D 200. 21. E-525	1149S 140. 16. E-1355	16
5.2	986A 24. 2.1 E-1578	977U 180. 17. E-618	989A 100. 10. E-1525	1005S 78. 8.9 D-1644	1000B 140. 13. E-1108	1023U 41. 5.2 E-1987	1071A 110. 11. E-1434	1101T 78. 9.3 E-1043	1105A 96. 9.3 E-1055	1137T 89. 8.9 D-1422	11248 230. 21. E-454	1147U 81. 8.9 E-1257	10
2.6	985A 13. 1.1 E-4789	980V 89. 10. D-876	988A 30. 2.7 E-2527	1006T 34. 4.4 D-2900	1005B 34. 3.7 E-3497	1023V 27. 3.1 E-2451	1070A 63. 5.9 E-1648	1106S 27. 2.7 E-2367	10970 37. 3.7 E-1658	1139T 41. 4.1 E-1561	1117C 67. 5.9 E-1925	1152U 37. 4.1 E-2798	4.4
1.1	980A 9.3 0.92 E-3766	981S 14. 1.4 E-4481	9888 17. 1.4 E-3526	1005U 10. 1.1 E-2620	9998 21. 2.3 E-4129	1034T 5.6 0.65 E-4395	10708 41. 3.6 E-3185	1099S 8.5 1.1 D-2429	1104A 44. 4.1 E-2096	1139S 15. 1.4 D-5080	11218 30. 3.2 E-2450	1160V 20. 2.0 D-2956	1.9
0.37	9838 4.8 0.41 D-5227	980U 17. 1.5 E-2871	982A 7.0 0.67 E-4145	1009S 4.1 0.37 E-3660	9940 4.8 0.44 E-4410	1033U 2.0 0.22 D-4536	1072B 14. 1.3 E-3354	1096T 7.0 0.70 D-5052	1101A 12. 1.1 E-3321	1138S 4.1 0.52 E-4397	1121C 10. 0.96 E-3962	1160S 18. 2.0 E-3290	0.85
CONTROL	981D 0 0 E-4473	975S 0 0 E-4567	9880 0 0 D-5609	999T 0 0 D-4971	994C 0 0 E-4567	1033S 0 0 E-5591	1072C 0 0 D-1950	1104T 0 0 E-5543	1100C 0 0 D-5322	1128U 0 0 E-3481	1122C 0 0 E-4787	1152T 0 0 E-4953	0
	984A 140. 14. E-702	=ANIMAL NUMBER =INITIAL LUNG BURDEN (KBQ) =INITIAL LUNG BURDEN (KBQ/KG) =D=DEAD, E=EUTHANIZED DAYS AFTER EXPOSURE AT DEATH											

Figure 8. Experimental design for dog study with 3.0 μm AMAD monodisperse particles of $^{239}PuO_2$ (Status as of 9-30-93).

Descriptions of the major clinical and pathology findings for each dog have been included in the annual report for the year in which the dogs died; survival data are summarized in Figures 9-11. Exposure information and dosimetry results for each dog are given in Appendix A.

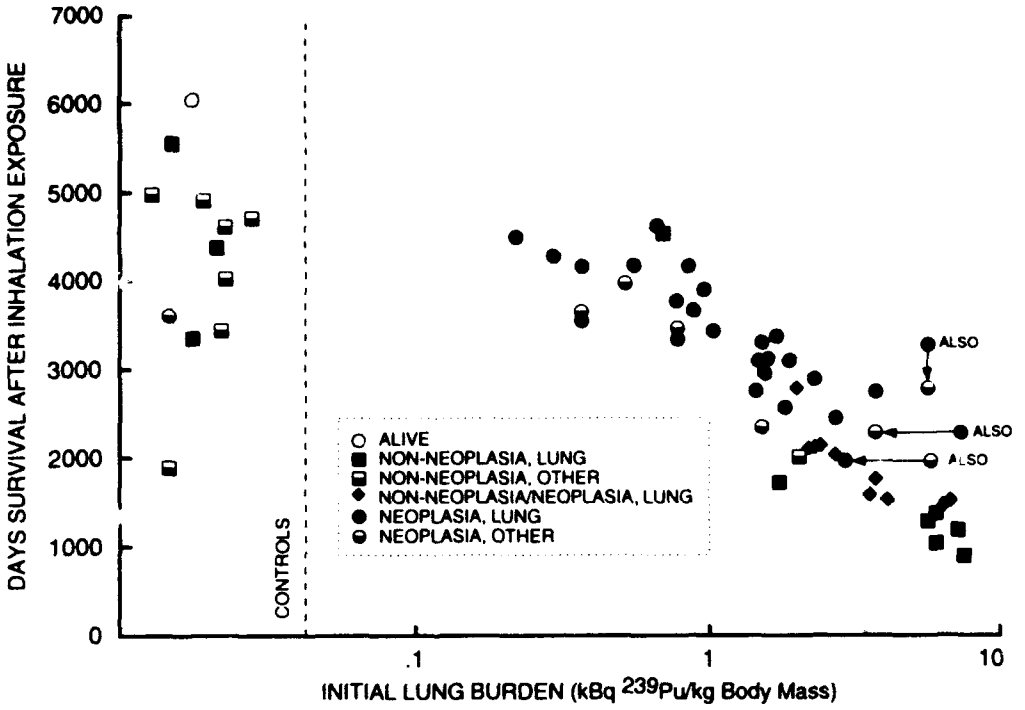


Figure 9. Survival of dogs that inhaled 0.75 μm AMAD monodisperse particles of $^{239}PuO_2$ (Status as of 9-30-93).

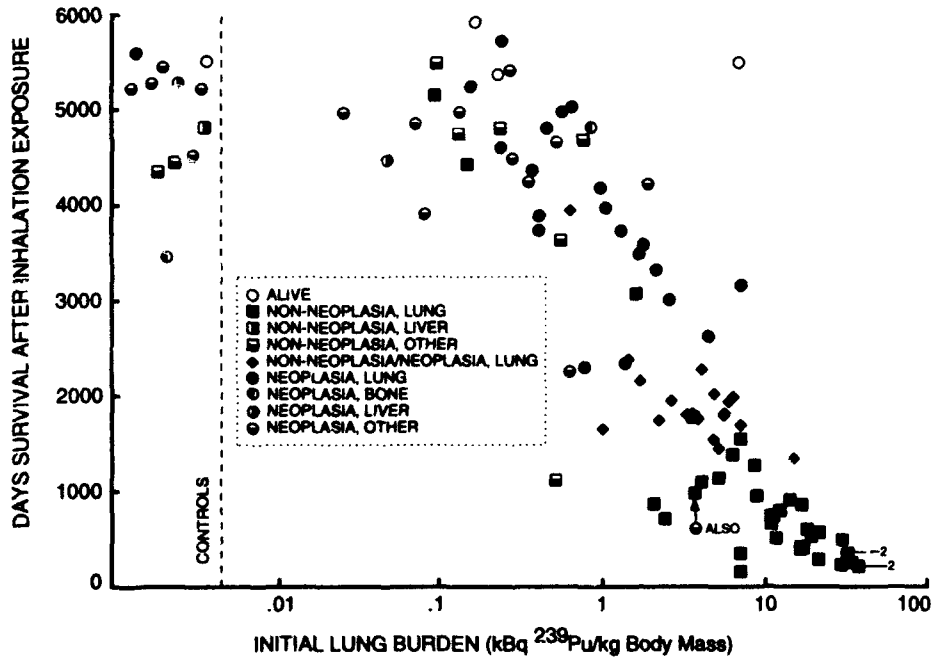


Figure 10. Survival of dogs that inhaled 1.5 μm AMAD monodisperse particles of $^{239}PuO_2$ (Status as of 9-30-93). Note that dogs having lung neoplasia as an incidental finding are designated as "non-neoplasia/neoplasia lung." Dogs in which lung neoplasia was a major finding are designated as "neoplasia, lung."

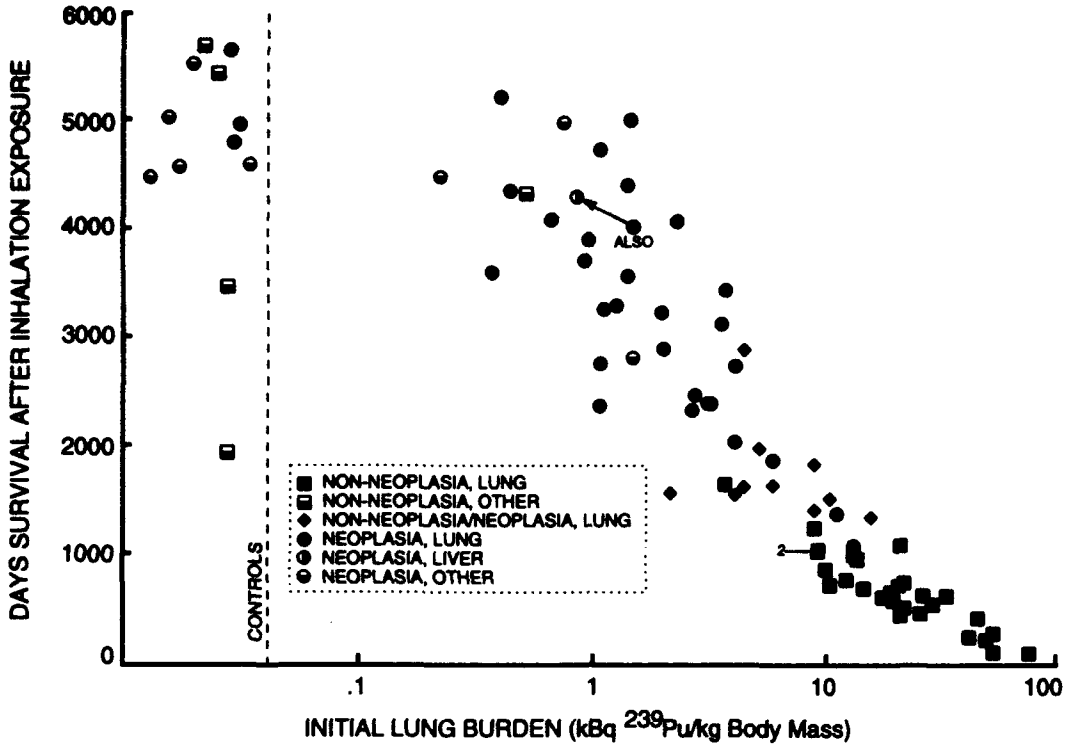


Figure 11. Survival of dogs that inhaled 3.0 μm AMAD monodisperse particles of $^{239}PuO_2$ (Status as of 9-30-93).

During the past 2 yr, 28 dogs died. Eleven were dogs exposed to the 1.5-μm AMAD particles, two were exposed to the 3.0-μm particles, and 15 were control dogs exposed to the aerosol vehicle. The major clinical and pathological findings are summarized below. As of September 30, 1993, 213 ^{239}Pu-exposed and 34 control dogs from these three studies were dead. The major findings at death from all of these dogs are summarized in Tables 4-6. We continue to observe the three ^{239}Pu-exposed and two control dogs that remain alive at 15 to 17 yr after exposure.

In the study involving inhalation of monodisperse 0.7 μm AMAD aerosols of $^{239}PuO_2$, three deaths occurred during the past 2 yr all in control dogs that were only exposed to the aerosol vehicle.

Dog 1095T, a female control, was found dead 5553 days after exposure. She was treated for bronchopneumonia about 3 mo before death and had recovered. At necropsy, cardiomegaly and ventricular myocardial hypertrophy were found indicative of heart failure. Pulmonary edema was the immediate cause of death. Several benign tumors were found, multiple uterine fibromas, mammary adenomas, a parathyroid adenoma, and bilateral adrenal cortical adenomas.

Dog 1106A, a male control, was euthanized in renal failure 4899 days after inhalation exposure. At necropsy the dog had marked chronic nephropathy with cortical atrophy and replacement with fibrosis; marked anemia was present secondary to the uremia of renal disease.

Dog 1146S, a female control, was euthanized with a fever of unknown origin 4705 days after inhalation exposure. At necropsy, multiple sites of periarteritis and necrotizing arteritis were found affecting primarily heart, lymph nodes, adrenals, and ovaries. The lesions were consistent with canine polyarteritis syndrome. A mild chronic nephropathy and lymphocytic nephritis were present. The only neoplasm present was bilateral adrenocortical adenoma.

Table 4

Summary of Major Findings at Death in Dogs Exposed by Inhalation to Aerosols of Monodisperse 0.75 μm Particles of $^{239}PuO_2$ (Status as of 9-30-93)

	Number of Dogs	ILB[a] (kBq ^{239}Pu/kg Body Weight)	Survival Times (Days after Exposure)	Cumulative Radiation Dose to Lung (Gy)
^{239}Pu-Exposed				
Non-Neoplasia				
Lung	7	0.7-7.4	891-4526	6.0-41
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	1	2.0	2007	15
Neoplasia				
Lung Injury with Lung Neoplasia	10	2.0-6.7	1467-2741	13-31
Lung	26[b,c,d]	0.22-5.6	1961-4618	2.0-26
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	7[b,c,d]	0.30-5.6	1961-3970	2.8-23
Control				
Non-Neoplasia				
Lung	3	--	3349-5552	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	7	--	1893-4977	--
Neoplasia				
Lung Injury with Lung Neoplasia	0	--	--	--
Lung	0	--	--	--
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	1	--	3609	--

[a]ILB=Initial lung burden based on whole-body counting of ^{169}Yb.
[b]One dog had a lung tumor and a brain meningioma.
[c]One dog had a lung tumor and a fibrosarcoma in the mediastinum.
[d]One dog had a lung tumor and a muscle fibrosarcoma.

Table 5

Summary of Major Findings at Death in Dogs Exposed by Inhalation to Aerosols of Monodisperse 1.5 μm Particles of $^{239}PuO_2$ (Status as of 9-30-93)

	Number of Dogs	ILB[a] (kBq ^{239}Pu/kg Body Weight)	Survival Times (Days after Exposure)	Cumulative Radiation Dose to Lung (Gy)
^{239}Pu-Exposed				
Non-Neoplasia				
Lung	35[b]	0.085-37	152-5203	0.9-59
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	8[d]	0.089-0.74	1109-5483	0.98-7.6
Neoplasia				
Lung Injury with Lung Neoplasia	19	0.63-15	1333-3945	4.9-49
Lung	21[d]	0.089-7.0	2340-5732	0.98-51
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	1	0.85	4860	7.1
Bone Marrow	0	--	--	--
Liver	1	0.48	4516	0.40
Other	11[b,c]	0.067-3.7	973-5309	0.55-15
Control				
Non-Neoplasia				
Lung	0	--	--	--
Bone Marrow	0	--	--	--
Liver	1	--	4793	--
Other	3	--	4342-5216	--
Neoplasia				
Lung Injury with Lung Neoplasia	0	--	--	--
Lung	1	--	5595	--
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	1	--	3472	--
Bone Marrow	0	--	--	--
Liver	1	--	5270	--
Other	4	--	4503-5428	--

[a]ILB=Initial lung burden based on whole-body counting of ^{169}Yb.
[b]One dog had lung injury and a kidney carcinoma.
[c]One dog had lung carcinoma and laryngeal carcinoma.
[d]One dog had lung adenoma and kidney nephropathy.

Table 6

Summary of Major Findings at Death in Dogs Exposed by Inhalation to Aerosols of Monodisperse 3.0 μm Particles of $^{239}PuO_2$ (Status as of 9-30-93)

	Number of Dogs	ILB[a] (kBq ^{239}Pu/kg Body Weight)	Survival Times (Days after Exposure)	Cumulative Radiation Dose to Lung (Gy)
^{239}Pu-Exposed				
Non-Neoplasia				
Lung	29	3.7-74	105-1658	24-77
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	2[c]	0.41,0.52	4397,5227	4.3,5.6
Neoplasia				
Lung Injury with Lung Neoplasia	10	2.2-16	1355-2900	13-84
Lung	29[b,c]	0.37-13	1108-5227	3.9-85
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	0	--	--	--
Bone Marrow	0	--	--	--
Liver	1[b]	0.85	4355	9.4
Other	3	0.22,1.5	2871,5052	2.5,13
Control				
Non-Neoplasia				
Lung	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	4	--	1950-5322	--
Neoplasia				
Lung Injury with Lung Neoplasia	0	--	--	--
Lung	3	--	4787-5591	--
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	5	--	4473-5609	--

[a]ILB=Initial lung burden based on whole-body counting of ^{169}Yb.
[b]One dog had lung and liver tumors.
[c]One dog had congestive heart failure and lung carcinoma.

Eleven dogs that inhaled 1.5 μm AMAD particles of $^{239}PuO_2$ and six control dogs that were only exposed to the control vehicle died during the past 2 yr.

Dog 1134S, a female with an ILB of 0.74 kBq ^{239}Pu/kg body weight, was found dead 4732 days after inhalation exposure. The dog had a long history of spondylosis and osteoarthritis. Renal insufficiency was noted several weeks before death.

At necropsy, large renal infarcts were found as the immediate cause of death. However, the marked renal cortical atrophy present was indicative of previous infarcts. Chronic renal insufficiency was evidenced by pulmonary gastric and vascular metastatic calcification and bilateral parathyroid hyperplasia. Neoplasms noted were an adenoma of the pars distalis of the pituitary, a benign mammary mixed tumor, a complex tubular adenoma, and mammary anaplastic carcinoma that infiltrated but did not metastasize.

Dog 1112U, a female with an ILB of 0.59 kBq ^{239}Pu/kg body weight, was euthanized in a comatose condition 5057 days after inhalation exposure. The dog had numerous clinical problems over its lifetime. Most significant was chronic liver disease. At 4 yr of age, laparotomy was performed to reduce inspissated bile in the gall bladder. Liver enzymes were periodically elevated throughout life. About 1 yr before death, the dog was placed thoroughly on thyroid replacement and treated for ulcerative keratitis. The dog was subsequently treated several times for ulcerative keratitis. In the terminal episode, the dog was found comatose with a depressed body temperature. The dog did not respond to treatment, and euthanasia was recommended.

At necropsy, lesions found were generally not severe enough to produce clinical disease except for a suppurative bronchopneumonia. Three neoplasms were found, bronchioloalveolar carcinoma of the lung, cortical adenoma of the adrenal, and follicular cell adenoma of the thyroid. However, all were small and probably sub-clinical. The liver had focal capsular fibrosis and multiple micro granulomas but ample normal parenchyma to sustain normal hepatic function.

Dog 1146T, a female with an ILB of 0.55 kBq ^{239}Pu/kg body weight, died during anesthesia for diagnostic radiography 5023 days after exposure. Over the years, the dog had numerous, minor clinical problems including lymphopenia, patellar luxation, and tooth extractions. About 1.5 yr before death, five mammary tumors were removed, including one noninvasive adenocarcinoma. A tumor of the lung was noted on radiographs about 6 mo before death. Seven months before death, persistent diarrhea was present. Signs of intestinal disorder became more severe and, at 5 mo before death, an adenocarcinoma of the ileum was surgically removed. The immediate cause of death was cardiopulmonary failure as indicated by hydrothorax, ascites, and pulmonary edema seen at necropsy. The pulmonary tumor was a primary bronchioloalveolar carcinoma confined to the left cardiac lobe and did not appear to contribute to the clinical disease. Other, noncontributory neoplasms found were adenocarcinoma of the pancreas, bilateral adrenocortical adenomas, and adenoma of the pituitary. There was no recurrence of the ileal tumor.

Dog 1153S, a female with an ILB of 0.44 kBq ^{239}Pu/kg body weight, was euthanized 4845 days after inhalation exposure with a lung carcinoma. Three weeks before death, the dog was examined because of a poor appetite. The respiratory rate was elevated. The dog had a previous history of radiation pneumonitis 7 yr before and had been placed on special observation repeated times. During those observations, radiographic changes were minimal or mild. Upon bronchoscopic evaluation, the airways were normal. However, bronchial lavage revealed anaplastic epithelial cells indicative of a pulmonary carcinoma.

At necropsy, an adenocarcinoma with an alveolar pattern was found diffusely infiltrating all lung lobes. The anaplastic cells formed numerous small foci with alveolar or papillary forms and filled alveoli in some areas with cohesive cells. The neoplasm metastasized by the vasculature to the heart, stomach, and lymph nodes of the thoracic cavity. Lymphoid atrophy of tracheobronchial lymph nodes and fibrosis in the alveolar septa and pleura were also prominent.

Dog 988U, a female with an ILB of 0.26 kBq ^{239}Pu/kg body weight, was euthanized with disc disease 5483 days after inhalation exposure. At necropsy, an invasive thyroid follicular cell carcinoma was found. The carcinoma had metastasized to the lung, larynx, and cervical lymph nodes. The cause for the terminal illness, however, was a ruptured intervertebral disc with spinal cord compression. Numerous other benign tumors were also present including ovarian adenoma, ovarian granulosa cell tumor, adrenocortical adenoma, and multiple mammary adenomas.

Dog 994B, a male with an ILB of 0.23 kBq ^{239}Pu/kg body weight, died in renal failure 5732 day after inhalation exposure. The dog had a long history of renal insufficiency.

At necropsy, a chronic interstitial nephritis and nephrosclerosis were found. A necrotizing pancreatitis was also present that contributed significantly to the death. In addition, several significant tumors were found that were incidental to the death. These included a papillary adenocarcinoma of the lung, a follicular carcinoma of the thyroid, an islet cell carcinoma of the pancreas, and a pheochromocytoma of the adrenal.

Dog 1100A, a male with an ILB of 0.23 kBq ^{239}Pu/kg body weight, was found dead 4841 days after inhalation exposure. The major clinical observation was a recurrent history of pneumonia leading to chronic obstructive lung disease. The dog was being treated for pneumonia when it was found dead.

At necropsy, the principal lesions were found in the adrenals and lungs. Both adrenals were completely necrotic; adrenal failure was the cause of the death. The pulmonary lesions of chronic obliterative bronchiolitis could have also added to the cause of death. Incidental neoplasms were a pituitary adenoma, renal fibroma and uterine leiomyoma.

Dog 1154S, a female with an ILB of 0.13 kBq ^{239}Pu/kg body weight, was found dead 5016 days after exposure. At necropsy, segmental infarction of the jejunum and ileum was found as the immediate cause of death. Bilateral pheochromocytomas of the adrenals were present. Hypersecretion of catecholamines from these tumors may have been the cause of the intestinal infarcts. Other lesions were minimal. The only neoplasms noted were an adenoma of the ovary and an adenoma of the thyroid.

Dog 1149T, a female with an ILB of 0.12 kBq ^{239}Pu/kg body weight, was found dead 4790 days after inhalation exposure. The dog had a long history of an elevated respiratory rate (> 40/min) and erythrocytosis. Two years before death, there was radiographic evidence of chronic heart failure (cardiomegaly and pulmonary interstitial pattern). On the day of death, she was anesthetized for routine radiography. The recovery was apparently normal, but she was found dead in the early morning.

At necropsy, pulmonary edema was considered the immediate cause of death. Cardiomegaly and ventricular myocardial hypertrophy were found, indicative of cardiomyopathy. These lesions of long standing may well have predisposed the dog to cardiopulmonary failure following anesthesia. Several neoplasms were found, but all were incidental. There were adrenal cortical adenoma and parathyroid gland adenoma.

Dog 971C, a male with an ILB of 0.089 kBq ^{239}Pu/kg body weight, was euthanized in renal failure 5544 days after inhalation exposure. At necropsy, a severe chronic nephropathy was found with glomerular, tubular, and interstitial lesions that were responsible for the clinical disease and subsequent euthanasia. Marked atrophy of the tracheobronchial lymph nodes and a papillary cystic adenoma of the lung were incidental findings.

Dog 1131B, a male with an ILB of 0.085 kBq ^{239}Pu/kg body weight, was found dead 5203 days after exposure. The dog had a history of heart failure. At necropsy, lesions of cardiac failure were found, ventricular myocardial hypertrophy, ventricular dilation, pulmonary edema, and hepatic congestion. Marked thyroid atrophy was also present indicating that hypothyroidism may also have been a factor in the dog's clinical health.

Dog 960T, a female control, was euthanized 5428 days after inhalation exposure. The dog had a long medical history of mammary tumors. Five days before death, signs of central nervous system dysfunction developed, including inability to stand and paddling movements. The dog did not respond to treatment and became comatose.

At necropsy, an anaplastic mammary carcinoma was found with metastasis to other mammary glands, kidneys, and numerous local lymph nodes. The cause for the comatose condition, however, was multiple infarcts in the cerebral cortex and left ventricular myocardium. A cause for the brain and heart lesions was not found, but appeared not to be due to metastasis of the anaplastic mammary carcinoma. Numerous other lesions were found but were considered lesions of aging and not contributory to the terminal condition. These lesions included thyroid adenoma, adrenocortical adenoma and hyperplasia, nephrosclerosis, and mucocystic hyperplasia of the gallbladder.

Dog 998A, a male control, was euthanized with a lung carcinoma 5595 days after inhalation exposure. The dog had a prolonged history of minor clinical problems. In addition, prostatomegaly was first noted about 3 yr before death. This enlargement was accompanied by a bacterial cystitis that was treated successfully. Enlargement was noted again about 1 yr before death and was diagnosed as a bladder carcinoma. A lung tumor was first noted in the left apical lobe about 16 mo before death. It increased in size until it measured 2 x 1.5 x 1.5 cm 2 mo before death.

At necropsy, a papillary adenocarcinoma was found in the left apical lobe that had metastasized to the tracheobronchial lymph nodes. An adenocarcinoma of the prostate was also present. It had metastasized to the iliac and colonic lymph nodes. A transitional cell carcinoma was found in the bladder but had not metastasized. Benign neoplasms noted were a carotid body tumor, bilateral interstitial cell adenoma of the testicles, a thyroid adenoma, and a sebaceous adenoma of the skin.

Dog 1021S, a female control, was euthanized with marked ascites 5270 days after inhalation exposure. At necropsy, a large hepatocellular carcinoma with ascites and widespread metastasis in the peritoneal cavity and hepatic lymph nodes was found. Other lesions in other organs were few and incidental.

Dog 1107S, a female control, was euthanized in renal failure 5235 days after exposure. The dog had a history of renal insufficiency. Terminally she developed hindlimb paralysis. At necropsy, a marked nephrosclerosis with atrophy was present. A large thrombus was found blocking the terminal aorta and iliac arteries. These lesions were responsible for the clinical signs leading to euthanasia. In addition, several neoplasms were present but did not contribute to death. These included a metastasizing mammary carcinoma, bilateral ovarian adenomas, a thyroid adenoma, a pituitary adenoma, and a granular cell tumor of the urinary bladder.

Dog 1136S, a female control, was euthanized in hepatic failure 4793 days after inhalation exposure. The dog had a long history of hepatic disease; increased liver-related serum enzymes were first noted 9 yr before death. Acute hepatitis was diagnosed about 6 mo before death. Elevated serum alkaline phosphatase and hyperbilirubinemia was noted. Severe icterus developed several days before death.

At necropsy, the principal alterations were in the liver and had both acute and chronic features. The lesions included multiple foci of coagulative necrosis with infiltrates of neutrophils in some foci, focal biliary duct hyperplasia with lymphocytic infiltrates, and focal vascular degeneration of hepatocytes and multiple thrombosed veins. Lesions in other organs were minimal and insignificant. Mammary adenocarcinomas were removed about 1½ yr before death and had not recurred.

Dog 1152S, a female control, was euthanized with metastatic tumor 5252 days after exposure. About 2 yr before death, two malignant mammary tumors had been removed. About 6 mo before death, a lung density was noted on radiographs. Shortly thereafter, malignant tumors were surgically removed from the mammary glands. Terminally, the local mammary lymph nodes were enlarged, the lung mass was enlarging, and the distal extremities were swelling. At necropsy, a metastatic mammary solid carcinoma was found in local lymph nodes and lung. Other neoplasms were an adenoma of the thyroid and acinar cell adenoma of the pancreas.

In the study involving inhalation of 3.0-μm AMAD particles, two ^{239}Pu-exposed dogs and six control dogs that were only exposed to the aerosol vehicle died during the past 2 yr.

Dog 1139S, a female with an ILB of 1.4 kBq ^{239}Pu/kg body weight, was found dead 5080 days after exposure. The dog had a long history of autoimmune hemolytic anemia and liver disease. About 18 mo before death, lung tumors were noted radiographically. These slowly increased in size, resulting in the terminal episode of pulmonary insufficiency. At necropsy, hydrothorax secondary to the lung tumors was found as the immediate cause of death. The carcinoma of the lung was widespread through all lobes and had metastasized to the local lymph nodes. In addition to the lung tumor, a tubular cell carcinoma of the kidney, a mammary adenoma, and an adrenal cortical adenoma were found.

Dog 1096T, a female with an ILB of 0.70 kBq ^{239}Pu/kg body weight, was found dead 5052 days after inhalation exposure. About 5 mo before death, hyperadrenocorticism was diagnosed and treated with chemical suppression therapy.

At necropsy, a large pituitary carcinoma that compressed and invaded the brain was found. Bilateral adrenal cortical adenomas were also present. The clinical disease of hyperadrenocorticism was most likely due to the functioning adrenal cortical adenomas induced by secretion from a functional pituitary gland adenoma. The dog also had a marked suppurative broncopneumonia that contributed to the death. Other lesions were considered noncontributory and incidental.

Dog 988D, a male control, died 5609 days after inhalation exposure. The dog had a long history of numerous minor clinical signs. Erythrocytosis, neutrophilia, neutropenia, eosinophilia, lymphocytosis, and lymphopenia were all noted at one time or another. Prostamegaly and testicular atrophy both occurred about 8 yr before death and continued thereafter. Severe spondylosis and reduced weight were also noted for much of the life span. In the terminal episode, the dog was performing the Morris water maze test for cognitive function when it apparently inhaled some water and developed pulmonary edema. In spite of intensive treatment, the animal died 6 h later.

At necropsy, an acute inhalation pneumonia with pulmonary edema was found as the cause of death. The dog also had a severe focal ulcerative jejunitis that may have resulted in clinical disease. Numerous aging incidental, nonneoplastic lesions were noted including adrenocortical hyperplasia, testicular atrophy, and interstitial nephritis. Several incidental tumors noted were follicular thyroid carcinoma, solitary renal lymphoma, ossifying renal fibroma, testicular interstitial cell adenoma, and melanoma of lymph node.

Dog 1033S, a female control, was euthanized 5591 days after exposure. A chest mass was noted radiographically about 20 mo before death. This mass was monitored closely and grew slowly in size. In the terminal illness, the dog had lameness and weakness.

At necropsy, a primary pulmonary adenocarcinoma was found that had metastasized widely throughout the lungs and to the heart, kidneys, intestine, spleen, humerus, and local lymph nodes. Other lesions were few and included an adenoma of the pars distalis of the pituitary gland, a thyroid adenoma, and a pheochromocytoma.

Dog 1100C, a male control, was found dead 5322 days after exposure. He had a long history of renal disease and heart valve alterations. At necropsy, findings of endocardial fibrosis and ventricular myocardial hypertrophy were indicative of valvular insufficiency. Pulmonary edema was the immediate cause of death. The only neoplasm found was an endocrine carcinoma of the mediastinum.

Dog 1104T, a female control, was euthanized 5543 days after exposure with a widespread mammary carcinoma. An adenocarcinoma had been removed from the mammary gland about 18 mo before death. At necropsy, anaplastic mammary carcinoma was found in several mammary glands and the surrounding skin, local lymph nodes, urinary bladder, and lungs. Other lesions were minimal but included a mammary adenoma and an adrenal cortical adenoma.

Dog 1122C, a male control, was euthanized 4787 days after inhalation exposure. A lung tumor was diagnosed radiographically about 1 yr before death. At necropsy, a papillary adenocarcinoma of the right apical lobe of the lung was found. Numerous incidental lesions were noted including a testicular seminoma, renal fibroma, and mammary adenoma.

Dog 1152T, a female control, was euthanized 4953 days after inhalation exposure with a lung carcinoma. A lung mass was first noted on radiograph about 10 mo before death and confirmed as a carcinoma with brush biopsy. A mammary mass was noted 6 mo before death. The lung mass progressively increased in size. Facial and sciatic nerve injury developed, resulting in the recommendation for euthanasia.

At necropsy, a large lung mass (5 x 5 x 3cm) was present in the right diaphragmatic lobe. Histologically, this tumor was an adenosquamous carcinoma that invaded walls of bronchi, large vessels, and lymphatics. Metastases from the carcinoma were found in the lymph nodes (tracheobronchial, sternal, and hepatic) and skeleton (scapulae, multiple vertebra). The bone metastases stimulated new bone proliferation that compressed on nerves and the spinal cord. The mammary gland tumor was a simple papillary cystic adenocarcinoma that had no apparent metastases. The only other neoplasm was an adrenal cortical adenoma. Other lesions found included nodular hyperplasia of the liver, uterine mucocystic hyperplasia, and myeloid hyperplasia of bone marrow.

b. Toxicity of ^{144}Ce Inhaled in a Relatively Insoluble Form by Immature Beagle Dogs. XXI.

Study Contact: B. B. Boecker

Immature Beagle dogs (3-mo-old) received single, brief inhalation exposures to ^{144}Ce in FAP as part of the ITRI studies on the effects of age at exposure on the resulting dose-response relationships, and are being followed for life-span observations. The study is comprised of 49 dogs that inhaled graded levels of ^{144}Ce, resulting in ILBs that ranged from 0.00015-5.2 MBq/kg body weight (0.004-140 Ci/kg), and five control dogs that inhaled FAP without ^{144}Ce. The exposures took place in 1972, 1973, and 1976. Specific details on experimental design considerations, metabolism, and dosimetry of the inhaled ^{144}Ce, and early occurring biological effects were presented in previous annual reports from this Institute, especially in LF-45 (1971-1972), LF-46 (1972-1973), and LF-49 (1973-1974).

Annual summaries for this study have also been included in all other annual reports to the present time. The current status of this study is shown in the experimental design chart given in Figure 12. Exposure information and dosimetry results are given for each dog in Appendix A. Survival data for dogs in this study are summarized graphically in Figure 13. The last living dog in this study, a ^{144}Ce-exposed dog, died during the 2-yr period covered by this report. Major clinical and pathology findings for this dog are summarized below. Also, the major findings in all 49 ^{144}Ce-exposed and five control dogs in this study are summarized in Table 7.

DESIGN MBQ/KG	A	B	C		D	E	MEAN MBQ/KG
3.7		6756 11. 4.4 D-85	671C 12. 3.1 D-121	6730 5.8 2.7 D-86	1022U 18. 5.2 D-91		3.7
2.8		6725 8.5 2.4 E-889	673C 5.2 2.6 D-911	6728 6.7 1.8 E-818	10275 8.5 2.9 D-738	1024D 10. 2.7 E-700	2.5
1.9	628A 3.7 1.4 E-2886	6757 3.4 1.0 E-1227	672C 5.7 1.8 D-1732		10337 3.5 1.4 E-3882	1028A 6.7 2.0 E-1314	1.5
0.93	6278 3.1 0.88 E-2341	6736 1.6 0.78 E-4841	673A 1.6 0.58 E-3326		10225 4.1 1.3 D-2887	1019A 4.8 1.4 D-1413	1.0
0.46	6308 0.98 0.34 D-4974	6715 1.1 0.41 E-4286	672A 1.5 0.44 D-1520		1021V 2.1 0.67 E-2913	1033B 1.3 0.44 E-2772	0.44
0.22	630A 0.65 0.22 E-3387	6737 0.20 0.12 D-4715	675B 0.48 0.19 D-3835		10236 0.58 0.25 W-3987	1018B 0.58 0.18 D-3883	0.19
0.044	6240 0.30 0.11 E-5286	6747 0.067 0.032 E-5805	671B 0.22 0.059 E-3832		1018U 0.15 0.037 D-5380	1017B 0.20 0.052 E-5025	0.059
0.0088	623A 0.041 0.010 E-5842	668U 0.018 0.0063 E-4288	668A 0.016 0.0052 E-5802		10217 0.078 0.026 E-4614	1018B 0.027 0.0070 D-3005	0.011
0.0017	624C 0.0067 0.0023 E-3870	6705 0.0015 0.00068 E-5108	671A 0.0068 0.0033 D-4154		10178 0.014 0.0044 E-4387	1021A 0.0074 0.0018 D-3885	0.0026
0.00033	624A 0.0018 0.00048 E-4785	668V 0.0004 0.00015 D-2338	671D 0.0006 0.00022 E-5813		1034U 0.0009 0.00032 E-5081	1033A 0.0012 0.00041 D-3870	0.00032
CONTROL	623B 0 0 E-4202	6686 0 0 E-4213	6686 0 0 D-5362		10136 0 0 D-4015	1016A 0 0 E-1378	0
	628A 3.7 1.4 E-2886	=ANIMAL NUMBER =INITIAL LUNG BURDEN (MBQ) =INITIAL LUNG BURDEN (MBQ/KG) =D=DEAD, E=EUTHANIZED, A=ALIVE-DAYS AFTER EXPOSURE AT DEATH					

Figure 12. Experimental design for studying the effects of ^{144}Ce in FAP inhaled by immature (3-mo-old) Beagle dogs (Status as of 9-30-93).

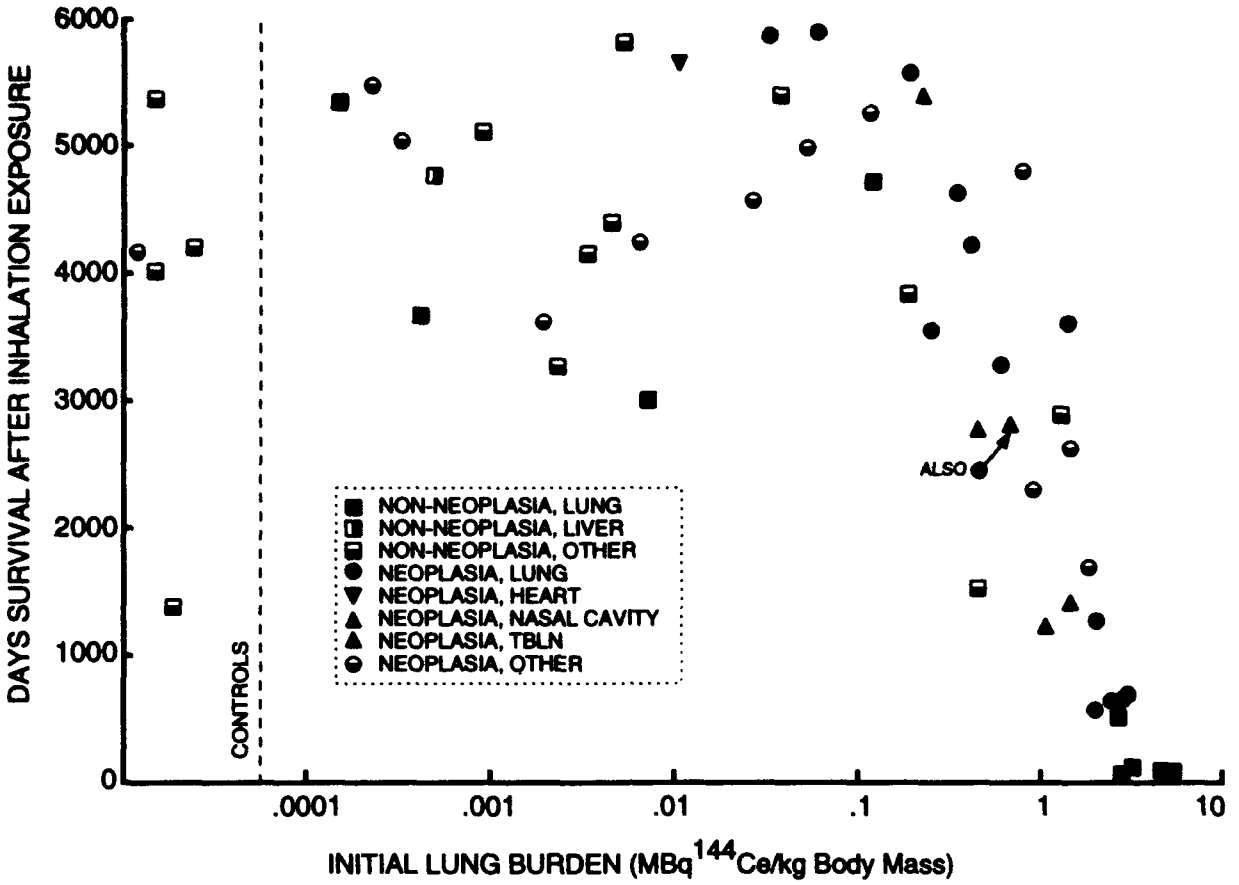


Figure 13. Relationships between the ILB of ^{144}Ce and survival time for Beagle dogs that inhaled ^{144}Ce in FAP when they were immature (3-mo-old) (Status as of 9-30-93).

Dog 1016B, a male with a lung burden of 0.89 MBq ^{144}Ce/kg body weight, died 5563 days after inhalation exposure. The dog had a long history of systolic heart murmur, osteoarthritis, patellar luxation, and spondylosis. About 1 yr before death, the dog had repeated episodes of bloat, and a 1.5 x 2 cm esophageal mass was excised. A lung tumor was noted at about the same time. The dog was in apparent good health but was found dead in the kennel.

At necropsy, an acute bronchopneumonia was found as the immediate cause of death. Two lung tumors were found, the largest in the right diaphragmatic lobe. The tumors had not metastasized but probably predisposed the dog to pneumonia. A malignant melanoma of the gingiva was also found, invading the mandible. This tumor had not metastasized. Other tumors were leiomyoma of the esophagus, adrenal cortical adenoma, and perineal adenoma.

Table 7

Summary of Major Findings at Death in Immature (3-mo-old) Dogs Exposed by Inhalation to ^{144}Ce in FAP (Status as of 9-30-93)

	Number of Dogs	ILB[a] (MBq ^{144}Ce/kg Body Weight)	Survival Times (Days after Exposure)	Cumulative Radiation Dose to Lung (Gy)
^{144}Ce-Exposed				
Non-Neoplasia				
Lung	9	.00015-5.2	66-5338	0.017-270
Bone Marrow	0	--	--	--
Liver	1	.00048	4765	0.054
Other	9	.00089-1.3	1520-5802	0.11-150
Neoplasia				
Lung Injury with Lung Neoplasia	0	--	--	--
Lung	14[b]	.032-2.9	618-5932	2.9-310
Nasal Epithelium	1	0.22	5387	33
TBLN	4[b]	0.44-1.4	1227-2813	51-180
Heart	0	--	--	--
Bone	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	12	.00022-1.8	1732-5642	0.024-220
Control				
Non-Neoplasia				
Lung	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	4	--	1378-5362	--
Neoplasia				
Lung Injury with Lung Neoplasia	0	--	--	--
Lung	0	--	--	--
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	1	--	4213	--

[a]ILB = Initial Lung Burden
[b]One dog had lung and TBLN tumors.

c. Toxicity of $^{239}PuO_2$ in Immature Beagle Dogs. XIII.

Study Contact: R. A. Guilmette

As part of the ITRI studies on the effects of age at exposure on the resulting dose-response relationships, immature Beagle dogs (3-mo-old at exposure) received single, brief inhalation exposures to a monodisperse aerosol of $^{239}PuO_2$ (1.5 μm AMAD) and are being followed for life-span observations. The experimental design consists of blocks of 12 dogs, each exposed to graded activity levels of ^{239}Pu that ranged from 20.7 to 0.0085 kBq/kg body mass; there were eight activity levels, with a total of 96 exposed dogs. Twelve control dogs exposed only to the aerosol vehicle were also included in the experiment. Two blocks of dogs were exposed in 1978. After a 2-yr break in exposures because of a colony outbreak of parvovirus enteritis, exposures were resumed in 1980 and continued through 1982. Specific details on experimental design considerations, metabolism, and dosimetry of the inhaled ^{239}Pu, and early occurring biological effects have been presented in previous annual reports from this Institute, especially in LF-69, LMF-102, LMF-113, LMF-114, and LMF-115. Annual summaries for this study have also been included in all other annual reports to the present time.

The current status of this study is shown in the experimental design chart given in Figure 14. Exposure information and dosimetry results are given for each dog in Appendix A. Survival data for dogs in this study are summarized graphically in Figure 15. During the past 2 yr, 19 Pu-exposed dogs died; four control dogs died. Summaries of the major clinical and pathological findings are presented below. As of September 30, 1993, there were 36 experimental and 7 control dogs alive on this study. A summary of the major findings in the dogs at death is given in Table 8. We continue to observe the dogs remaining alive at 11 to 14 yr after exposure.

DESIGN KBQ/KG	A	B	C	D	E	F	G	H	I	J	K	L	MEAN KBQ/KG
21	1215A 30. 5.9 E-2326	1217S 32. 8.1 E-1700	1331A 78. 19. D-1811	1331S 67. 24. D-46	1350A 70. 29. E-1909	1340T 33. 12. A-4410	1366C 63. 20. D-1422	1367S 67. 20. E-1580	1379A 120. 26. D-1663	1379T 100. 21. E-1506	1389A 78. 20. D-1352	1380V 110. 27. E-1937	19
10	12208 14. 5.9 E-3017	1222T 5.6 2.9 E-2773	1334B 4.1 1.3 A-4425	1331U 22. 7.8 E-2496	1350C 22. 8.9 E-1852	1351S 27. 10. E-1925	1366A 23. 5.9 E-2717	1365S 36. 10. E-1947	1378B 31. 7.0 D-739	1377T 37. 10. E-1386	1387B 19. 4.8 E-2294	1390S 24. 7.8 E-3254	7.0
5.2	1217A 9.3 1.9 D-4185	1220T 5.9 2.4 E-2995	1331C 3.4 0.69 D-750	1337T 21. 8.3 E-4055	1336D 22. 8.3 A-4418	1337U 17. 5.9 E-3649	1365A 18. 4.8 E-2307	1364S 22. 4.8 E-1981	1377A 13. 3.7 E-3435	1377S 14. 4.4 D-2218	1387A 8.9 2.0 E-2629	1387S 5.2 1.7 A-3940	3.7
2.6	12158 4.1 0.89 D-1556	1222S 3.1 2.0 D-4715	1320A 3.4 0.74 E-1834	1324T 14. 2.6 E-3514	1339A 9.6 2.7 A-4417	1338T 3.5 1.4 A-4417	1364A 8.1 2.1 E-3612	1363S 8.1 2.5 E-3856	1376A 5.9 2.7 A-4068	1376T 5.6 2.5 A-4068	1384B 12. 3.5 E-3844	1384S 9.3 3.3 E-2190	2.3
1.1	12200 1.9 0.85 E-4922	1220S 2.2 0.67 D-4693	1320C 3.0 0.74 E-2273	1320S 3.0 0.78 E-4410	1334D 4.4 2.1 A-4425	1341S 2.3 0.89 A-4410	1362A 4.4 10. A-4209	1362S 2.3 0.83 A-4209	1367B 5.2 1.1 A-4194	1368T 2.6 0.96 D-3102	1384A 5.9 1.6 A-4005	1382S 5.9 1.4 E-3459	1.1
0.37	1221C 0.48 0.20 D-844	1221T 0.85 0.48 D-4727	1335A 1.2 0.35 A-4424	1335T 0.10 0.034 A-4424	1340A 1.8 0.48 A-4411	1340S 0.55 0.21 E-3877	1352C 0.92 0.23 A-4318	1373T 1.9 0.44 A-4069	1374A 1.6 0.52 A-4069	1373U 2.0 0.52 D-2659	1381B 2.9 0.55 A-4003	1381T 2.4 0.55 A-4003	0.37
0.093	1217C 0.19 0.044 D-4975	1223S 0.21 0.078 A-5161	1318B 0.81 0.24 A-4556	1317U 0.074 0.021 E-3570	1342A 0.26 0.078 A-4391	1334S 0.67 0.18 A-4425	1357B 0.41 0.093 A-4283	1357S 0.41 0.13 E-488	1377B 0.74 0.17 A-4047	1378S 0.44 0.11 D-3788	1386A 0.41 0.096 A-3968	1386S 0.33 0.093 A-3968	0.11
0.0085	12148 0.21 0.035 E-4796	1217T 0.056 0.011 D-5156	1317A 0.052 0.013 E-1832	1319S 0.081 0.020 D-4404	1339B 0.063 0.021 A-4413	1338S 0.031 0.011 E-3973	1355A 0.074 0.015 A-4300	1355T 0.048 0.012 A-4300	1367A 0.063 0.013 E-3199	1368S 0.028 0.0093 A-4199	1381A 0.13 0.022 A-4003	1381S 0.12 0.030 A-4003	0.018
CONTROL	12168 0 0 D-250	1223T 0 0 E-4896	1318D 0 0 E-4345	1317S 0 0 A-4556	1345A 0 0 A-4384	1342T 0 0 A-4388	1353A 0 0 D-3776	1358S 0 0 D-3992	1368B 0 0 A-4194	1376U 0 0 A-4066	1386B 0 0 A-3985	1380W 0 0 A-4024	0
	1215A 30. 5.9 E-2326	=ANIMAL NUMBER =INITIAL LUNG BURDEN (KBQ) =INITIAL LUNG BURDEN (KBQ/KG) =D=DEAD, E=EUTHANIZED, A=ALIVE - DAYS AFTER EXPOSURE AT DEATH OR ON 9-30-93											

Figure 14. Experimental design for the study of dose-response relationships in immature Beagle dogs that inhaled 1.5 μm AMAD monodisperse $^{239}PuO_2$ (Status as of 9-30-93).

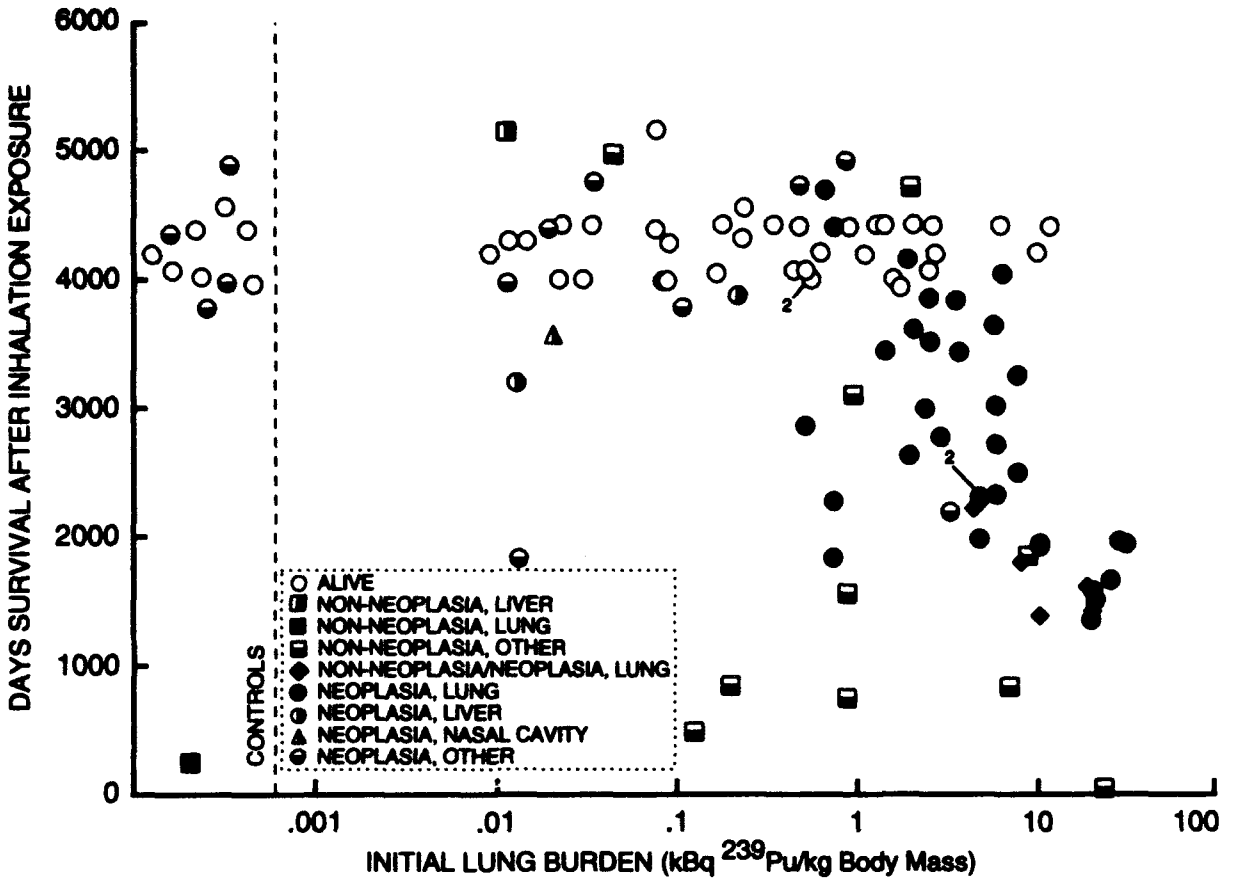


Figure 15. Relationship between ILB of $^{239}PuO_2$ and survival time for immature dogs (Status as of 9-30-93).

Dog 1390S, a female with a lung burden of 7.8 kBq ^{239}Pu/kg body weight, was euthanized with a lung carcinoma 3254 days after inhalation exposure. The dog had numerous clinical signs. About 2 yr before death, a lymphopenia developed that persisted until death. About 1 yr before death, a thoracic mass was noted on thoracic radiographs. This was diagnosed as a lung carcinoma 2 mo later. The mass remained asymptomatic until the dog began coughing blood, and euthanasia was recommended.

At necropsy, the lung was filled with bronchioloalveolar adenocarcinoma with the largest mass in the left diaphragmatic lobe. Numerous metastases were present in many parts of the lung, the tracheobronchial and mediastinal lymph nodes, and to the left adrenal. A second, incidental neoplasm was noted on the toe of the hind limb. A squamous cell carcinoma of the skin had replaced the nail bed and extended into the bone, but had not metastasized.

Dog 1378S, a female with an ILB of 7.0 kBq ^{239}Pu/kg body weight, died in cardiac arrest 3788 days after exposure. The dog had several clinical problems, the most severe being hypothyroidism, which was treated. In the terminal episode, the dog was examined for anorexia and incoordination. Intervertebral disc disease was suspected. Radiographs illustrated cardiomegaly and bronchopneumonia. Shortly after, the dog died in cardiac arrest.

At necropsy, a rhabdomyosarcoma was found in the left ventricular myocardium. The tumor protruded into the left ventricle partially occluding the left atrio-ventricular valve. It also extended into the intraventricular septum and the right ventricular myocardium. Metastatic rhabdomyosarcoma was present in vessels of the lung. Other neoplasms noted were an adrenal cortical adenoma, a vaginal polyp, a mixed mammary tumor, and a transitional cell carcinoma confined to the urinary bladder.

Table 8

Summary of Major Findings at Death in Dogs that Inhaled Monodisperse 1.5 μm AMAD Particles of $^{239}PuO_2$ when They Were Immature (Status as of 9-30-93)

	Number of Dogs	ILB[a] (kBq ^{239}Pu/kg Body Weight)	Survival Times (Days after Exposure)	Cumulative Radiation Dose to Lung (Gy)
^{239}Pu-Exposed				
Non-Neoplasia				
Lung	0	--	--	--
Bone Marrow	0	--	--	--
Liver	1	0.011	5155	0.05
Other	29	0.044-24	46-4975	0.12-8.7
Neoplasia				
Lung Injury with Lung Neoplasia	5	4.4-20	1386-2218	9.4-36
Lung	33[b]	0.021-29	1352-4410	0.05-84
Nasal Epithelium	1[b]	0.021	3570	0.05
TBLN	0	--	--	--
Heart	1	0.11	3788	0.31
Bone	0	--	--	--
Bone Marrow	1	0.85	4922	1.50
Liver	2[c]	0.013-.21	3199-3877	0.03-.46
Other	9[c]	.011-2.0	1832-4756	.026-6.6
Control				
Non-Neoplasia				
Lung	1	--	250	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	0	--	--	--
Neoplasia				
Lung Injury with Lung Neoplasia	0	--	--	--
Lung	0	--	--	--
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	4	--	3776-4896	--

[a]ILB = Initial lung burden based on whole-body counting of ^{169}Yb.
[b]One dog had nasal carcinoma and lung carcinoma.
[c]One dog had liver carcinoma and mammary carcinoma.

Dog 1337T, a female with an ILB of 6.3 kBq ^{239}Pu/kg body weight, was euthanized with pulmonary insufficiency related to pulmonary neoplasia 4055 days after exposure. The dog had few clinical problems until being placed in the hospital with dyspnea. Pulmonary neoplasia was suspected, but could not be visualized radiographically.

At necropsy, a bronchioloalveolar adenocarcinoma was found filling all lobes of the lung. There were mestatases to the thoracic lymph nodes. The only other neoplasm was a C-cell adenoma of the thyroid.

Dog 1377A, a male with a lung burden of 3.7 kBq ^{239}Pu/kg body weight, was euthanized with a lung carcinoma 3435 days after inhalation exposure. The dog had few clinical signs during its lifetime but did have parvovirus enteritis as a puppy. About 15 mo before death, a lung mass was noted radiographically. The mass slowly increased in size until respiratory distress became marked.

At necropsy, the principal disease was adenocarcinoma of the left apical cardiac lobe of the lung with metastases to other lung lobes and to the tracheobronchial, sternal, mediastinal, and hepatic lymph nodes. Other lesions were incidental. Neoplasms noted were an endochondroma of the epiglottis, seminoma and interstitial cell adenoma of the testes, and a papillary mesothelioma.

Dog 1384B, a male with an ILB of 3.5 kBq ^{239}Pu/kg body weight, was euthanized because of metastatic neoplasia 3844 days after exposure. A lung tumor in the left diaphragmatic lobe was noted 6 mo before death. A mass over the mandible was noted 8 days before death. Because of the worsening clinical condition and suggestion of metastasis, euthanasia was recommended.

At necropsy, the largest mass, a 3-cm diameter nodule in the left diaphragmatic lobe, was a primary squamous cell carcinoma of the lung. This tumor metastasized to the tracheobronchial lymph nodes. Also present in the lungs were two other, apparently separate, primary neoplasms, a papillary adenocarcinoma and a bronchioloalveolar adenocarcinoma. Neither of these metastasized. In addition, two tumors were found in the kidneys, apparently separate primary neoplasms, because they were each confined to separate kidneys. However, each metastasized to the lungs. The only other neoplasm noted was an interstitial cell adenoma of the testicle.

Dog 1363S, a female with an ILB of 2.5 kBq ^{239}Pu/kg body weight, was euthanized with a lung tumor 3858 days after exposure. A lung tumor was noted radiographically about 18 mo before death. The tumor slowly grew in size until it compromised pulmonary function.

At necropsy, a 7 x 7 x 5 cm mass was found in the right diaphragmatic lobe. Smaller (1 to 3 mm) nodules were present in other lobes. Histologically, the large mass was a bronchioloalveolar adenocarcinoma with intra-pulmonary metastases. Other lesions were few and insignificant. The only other neoplasm was an ovarian adenoma.

Dog 1364A, a male with an ILB of 2.1 kBq ^{239}Pu/kg body weight, was euthanized with a lung carcinoma 3612 days after inhalation exposure. The dog had few clinical problems until the day before death when it was presented for rapid respiration. On physical exam, the dog had a low grade fever and elevated heart and respiratory rates. Thoracic radiographs taken on the next day showed the left apical cardiac lobe to be filled with an apparent neoplasm. Because of the clinical condition, euthanasia was recommended.

At necropsy, a primary pulmonary adenocarcinoma was found apparently originating in the left apical cardiac lobe with extensive intra-pulmonary metastasis, primarily to the right apical lobe. Microscopic metastases were also present in the thoracic lymph nodes and epicardi[illegible]. The unusual feature of the tumor was the varied morphologic expression. Papillary, alveolar, squamous, [illegible]d transitional patterns were present although the papillary pattern predominated.

Dog 1222S, a female with an ILB of 2.0 kBq ^{239}Pu/kg body weight, was found dead 4715 days after inhalation exposure. The dog had a history of bloating after eating, but few other clinical problems.

At necropsy, there was marked dilation of the stomach with gas and undigested foodstuff, but no evidence of gastric torsion. The probable cause of death was cardiopulmonary failure as a consequence of the dilation and pressure on the great vessels. A closed suppurative endometritis was present as well as adeno-

cortical hyperplasia indicative of Cushing's disease. The pyometra and endocrine abnormalities may have contributed to the clinical disease. The only neoplasm present was a simple tubular adenoma of the mammary gland.

Dog 1382S, a female with a lung burden of 1.4 kBq ^{239}Pu/kg body weight, was euthanized with a lung carcinoma 3459 days after inhalation exposure. The dog had a 3.3 cm diameter mass in the right apical lobe diagnosed 2 mo before death. Just before death, she presented with a right front leg limnens, increased respiratory rate, and severe rales.

At necropsy, primary adenocarcinoma was found in the right apical lobe with intrapulmonary metastases, and metastases to the rib and thoracic wall mediastinum and the mediastinal, sternal, and tracheobronchial lymph nodes. The only other neoplasm was a complex tubular adenoma of the mammary gland that was incidental.

Dog 1220D, a male with an ILB of 0.85 kBq ^{239}Pu/kg body weight, was euthanized 4922 days after exposure because of a hyperviscosity syndrome secondary to a multiple myeloma. The dog had a thyroid carcinoma removed about 3 mo before death. At that time, hyperproteinemia was noted. Three weeks before death, a monoclonal gammopathy was documented, and a bone marrow aspirate showed numerous plasma cells resulting in a diagnosis of plasma cell sarcoma (multiple myeloma). A week later, a large cutaneous infarct developed in the thorax.

At necropsy, myeloma cells were found in numerous organs, marrow, liver, kidneys, and spleen. In addition, two primary lung tumors were noted, both bronchioloalveolar carcinomas. Other neoplasms were recurrence of the thyroidal carcinoma, testicular interstitial cell adenoma, and testicular seminoma.

Dog 1320S, a female with an ILB of 0.78 kBq ^{239}Pu/kg body weight, was euthanized because of bronchopneumonia secondary to a lung tumor 4410 days after exposure. The dog had few minor clinical problems before the terminal episode. A lung mass was noted radiographically 40 mo before death that measured 1.5 x 2.0 cm. The mass changed in size and degree of consolidation over the next several years. Two weeks before death, multiple cavitations were present. When persistent secondary pneumonia developed, euthanasia was recommended. At necropsy, a papillary adenocarcinoma was found filling the left apical cardiac lobe. Metastases were present in the thoracic lymph nodes. No other neoplasms were present.

Dog 1220S, a female with an ILB of 0.67 kBq ^{239}Pu/kg body weight, was found dead 4693 days after inhalation exposure. The dog had a long history of medical problems. Four years before death, the right thyroid was removed because of a follicular carcinoma. In spite of the malignant nature of the tumor and obvious invasion of vessels, no pulmonary metastases were noted during the next year when numerous thorax radiographs were taken. In the terminal illness, pulmonary disease was suspected, but the dog died unexpectedly shortly after initiation of treatment for pneumonia.

At necropsy, a pleural effusion was found as the immediate cause of death. A large adenosquamous carcinoma was found as a primary tumor in the left apical cardiac lobe of the lung. The neoplasm had metastasized to other lobes of the lung, trachea, mediastinum, and sternal and mediastinal lymph nodes.

Dog 1221T, a female with an ILB of 0.48 kBq ^{239}Pu/kg body weight, died 4727 days after exposure. The dog had a long history of minor clinical problems. About 2 yr before death, a splenectomy was performed for a large hematoma. In the terminal episode, the dog was admitted for anorexia. On physical exam, she had a fever and depression. Generalized alopecia and mammary tumors were noted. She had a long history of phenobarbital therapy for seizures and, in the prior year, hepatic enzymes were mildly but persistently elevated. The dog died that night before a further clinical examination could be performed.

At necropsy, a lymphosarcoma confined to the abdomen, except for the thoracic lymph nodes, was considered the primary cause of death. The lymphosarcoma invaded the liver, adrenals, ovary, bone marrow, and abdominal lymph nodes. The immediate cause of death was a suppurative meningitis. Other tumors noted were adrenocortical carcinoma, multiple complex adenomas of the mammary gland, and multiple sebaceous adenomas.

Dog 1340S, a female with an ILB of 0.21 kBq ^{239}Pu/kg body weight, was euthanized with an inoperable abdominal mass 3877 days after inhalation exposure. The dog had few clinical problems until the terminal illness. At that time, several mammary tumors were present.

At necropsy, a solid mammary carcinoma was found that had metastasized to all lobes of the lungs, liver, and lumbar vertebra and local lymph nodes. The abdominal mass was a large cholangiocarcinoma that measured 9 x 7 x 6 cm at its greatest dimension. This neoplasm had not metastasized. No other neoplasms were encountered.

Dog 1217C, a male with an ILB of 0.044 kBq ^{239}Pu/kg body weight, was found dead 4975 days after exposure. The dog had an uneventful clinical history. At necropsy, a marked ventricular myocardial hypertrophy indicative of valvular insufficiency was found. Few other lesions were present. Of particular interest were a mastocytoma of the skin and a follicular cell carcinoma of the thyroid. Neither of these tumors was metastatic nor invasive.

Dog 1214B, a male with an ILB of 0.035 kBq ^{239}Pu/kg body weight, was euthanized 4756 days after inhalation exposure with a large mass in the throat region. The dog had a number of minor clinical problems during its life. A thyroid-stimulating hormone test about 4.5 yr before death indicated hypothyroidism. After 2 yr of treatment it was euthyroid, but hypothyroid again 1 yr before death. About 5 wk before death, an invasive amelanotic melanoma was removed from the oral cavity. Euthanasia was recommended when massive lung metastases were seen on radiography.

At necropsy, the malignant melanoma was found to have invaded the soft tissues of the neck, salivary gland, veins, and cervical and retropharyngeal lymph nodes. The melanoma had also metastasized to the lungs, myocardium, adrenal medulla, larynx, and tracheobronchial, sternal, mediastinal axillary, and prescapula lymph nodes. The right thyroid was atrophic, and the left was overrun with a follicular carcinoma. Epidermal atrophy and hyperkeratosis as well as adenexial atrophy indicated a deficiency of thyroid hormones. Other tumors present were intratubular seminoma and esophageal leiomyofibroma.

Dog 1319S, a female with an ILB of 0.020 kBq ^{239}Pu/kg body weight, died shortly before surgery for mammary neoplasms 4404 days after exposure. The dog had numerous minor clinical observations. Two slowly growing mammary tumors were noted about 1 yr before death. They were scheduled for routine removal. During the surgical workup examination, periosteal proliferations and osteolysis were noted on radiographs of the sacral vertebrae. The dog was found dead in its cage on the morning of the scheduled surgery.

At necropsy, a widely metastatic mammary adenocarcinoma was found that had resulted in hydrothorax. The metastases involved the lung, mediastinum, omentum, mesentery, diaphragm, and axillary and thoracic lymph nodes. A myxoma was found in and around the muscles of the pelvis resulting in the radiographic bone lesions. Several benign tumors were found, hemangiomas of the subcutis and sinus mucosa, pituitary gland adenoma, and adrenal cortical adenoma.

Dog 1217T, a female with an ILB of 0.011 kBq ^{239}Pu/kg body weight, died in comatose condition 5155 days after exposure. The dog had a relatively uneventful medical history with minor clinical findings until the terminal episode. The only exception was hypothyroidism diagnosed and treated about 15 mo before death. Terminally, the dog was noted with bloody diarrhea and pale mucous membranes. The next morning, the dog was comatose with a profound anemia, hypoproteinemia, and thrombocytopenia.

At necropsy, a marked thyroidal atrophy was noted consistent with the clinical hypothyroidism. Most striking was an atrophy and marked hemorrhagic necrosis of the liver. Several benign neoplasms were present, a chemodectoma of the mediastinum, an adenoma of the gallbladder, and an adenoma of the mammary gland. A spindle cell carcinoma of the mammary gland was also noted, but it was not invasive.

Dog 1338S, a female with an ILB of 0.011 kBq ^{239}Pu/kg body weight, was euthanized with an inoperable tumor 3973 days after inhalation exposure. The dog had a prolonged clinical history of oral problems, including abscessed teeth, gingivitis, and epulis. The terminal episode related to a mass in the left tonsil discovered 5 days before death. The mass caused profuse salivation and anorexia. Because of the inoperable nature of the neoplasm, euthanasia was recommended.

At necropsy, the mass was found to be a poorly differentiated squamous cell carcinoma of the tonsil that extended into the adjacent salivary gland but had not metastasized. Other neoplasms noted were three adenomas of the mammary glands. Other lesions were minimal and incidental to the clinical disease.

Dog 1223T, a female control, was euthanized 4896 days after exposure. Several mastectomies had been performed with diagnoses of mixed mammary tumors, adenomas, and an adenocarcinoma. She had acute hepatitis about 6 mo before death which resolved in 3 wk. Enlarged submandibular and prescapular lymph nodes were observed about 6 wk before death. Lymphosarcoma was diagnosed based on several lymph-node aspirates. At necropsy, lymphosarcoma was found in most visceral and peripheral lymph nodes with infiltration of spleen, liver, stomach, kidneys, gall bladder, uterus, and mammary glands. Massive involvement of the liver had caused moderate hepatic necrosis. Other neoplasms noted were noncontributory and included renal fibroma, vaginal leiomyoma, and adrenal cortical adenoma.

Dog 1318D, a male control, was euthanized with an abdominal mass 4345 days after exposure. The dog had few medical problems in its life span. Diarrhea was noted about 6 mo before death, but resolved in 3 days. In the terminal episode, the dog was found comatose 1 day before death. Peritonitis with ascites was present, and a large mass was palpated in the abdomen. At necropsy, a lymphosarcoma was found greatly expanding a portion of the jejunum and invading the anterior mesenteric lymph nodes. Lymphosarcoma infiltrates were present in the tracheobronchial lymph nodes, but in no other place. Arterial thromboses were present in the lung which probably contributed to the poor clinical condition. A follicular cell adenoma was present in the thyroid.

Dog 1353A, a male control, was found dead 3776 days after exposure while on a treatment regimen for acute liver disease. The dog had few medical problems in its lifetime. Two days before death, the dog was examined for anorexia and rapid weight loss. Hepatitis was diagnosed and treatment initiated.

At necropsy, the dog was found to have malignant mastocytoma with massive infiltration of neoplastic cells in the liver, spleen, and adrenals. Less severe infiltration was present in kidneys and pituitary gland. The massive hepatic infiltrates caused an acute liver failure. Other lesions were minimal and incidental. The only other neoplasm was hemangioma of the popliteal lymph node.

Dog 1358S, a female control, died in renal failure 3992 days after exposure. In the terminal episode, the dog was thin and had oral ulcerations. She was treated for renal failure, but died several days later.

At necropsy, a marked nephropathy with nephrosclerosis was found. Ulceration of the gastric mucosa, calcification of the gastric mucosa and small arteries and hyperplasia of the parathyroid glands were all indications of renal failure and uremia. In addition, an undifferentiated sarcoma was found filling one half of one kidney. It did not spread outside the capsule of the kidney. A pituitary adenoma was also present.

d. Repeated Inhalation Exposure of Beagle Dogs to $^{239}PuO_2$. XVI.

Study Contact: J. H. Diel

To evaluate the role of chronic exposure to an alpha-emitting aerosol, PuO_2, compared to single acute uptakes of the same radionuclide, adult Beagle dogs inhaled a monodisperse aerosol of $^{239}PuO_2$ (0.75 μm AMAD) either once or once every 6 mo for 10 yr. Twenty-four singly exposed dogs received 3.7 kBq ^{239}Pu; the multiply exposed dogs received either 0.37 or 3.7 kBq per exposure for a maximum of 20 exposures each. There were 24 dogs exposed at the lower dose, and 15 dogs exposed at the upper dose. Nine additional dogs at the upper dose were sacrificed for dosimetry. Twelve control dogs were also given repeated, semiannual sham exposures for the 10-yr duration. These dogs are being held for life-span observations. The exposures began in 1977; the final repeated exposures were done in 1987. Specific details of the experimental design considerations, the dose-response models being tested, and the metabolism and dosimetry of the inhaled $^{239}PuO_2$ have been presented in previous annual reports, particularly in LF-58, LMF-91, and LMF-102. Annual summaries for this study have also been included in all other annual reports to the present time.

The current status of this study is shown in the experimental design chart given in Figure 16. Exposure information and dosimetry results are given for each dog in Appendix A. Survival data for dogs in this study are summarized graphically in Figure 17. During the past 2 yr, two of the singly exposed dogs and three control dogs died. The major clinical and pathological findings in these dogs are summarized below. As of September 30, 1993, one dog remained alive in this study. A summary of the major biological effects in all the ^{239}Pu-exposed and control dogs in this study is given in Table 9. Observations continue on the last living dog, which has been on study for 16 yr.

DESIGN EXPOSR	A	B	C	D	E	F	G	H	I	J	K	L	MEAN KBQ/EXP
SINGLE EXPOSR 3.7KBQ	1028A 5.6 1 E-4072	1040S 3.3 1 D-1651	1036A 3.0 1 E-3871	1050S 5.2 1 D-3564	1050A 4.1 1 E-5258	1055T 6.3 1 E-3558	1058B 5.6 1 E-4348	1062S 6.3 1 E-1030	1060B 4.8 1 E-2715	1077V 7.8 1 E-4097	1063C 4.1 1 D-3901	1073T 22. 1 E-1920	6.7
SINGLE EXPOSR 3.7KBQ	1026B 3.0 1 D-3740	1044U 3.3 1 E-4795	1025A 7.0 1 E-3612	1055W 5.6 1 E-4979	1050B 6.7 1 E-4856	1060S 6.3 1 E-3466	1051B 5.6 1 D-3809	1061T 7.8 1 E-3465	1061A 7.8 1 E-3339	1077S 7.8 1 D-3216	1067B 3.7 1 D-5517	1077U 9.6 1 E-4711	6.3
REPEAT EXPOSR 3.7KBQ	1027C 54. 10 E-2008	1036S 46. 9 E-1623	1040C 47. 9 E-1684	1055U 43. 10 E-1944	1045D 55. 10 D-1908	1049S 45. 8 E-1462	1051D 46. 9 E-1895	1061S 58. 9 E-1631	1062B 75. 10 D-2013	1069S 67. 9 D-1892	1064A 54. 9 E-1829	1070S 49. 10 D-2374	5.6
SACRIF REPEAT EXPOSR 3.7KBQ	1041A 21. 4 S-728	1037T 54. 10 D-1698	1037A 62. 8 E-1530	1049T 10. 2 S-369	1040D 9.3 2 S-364	1049V 57. 7 E-1267	1054D 61. 10 S-1838	1065T 24. 4 S-728	1054C 47. 9 S-1832	1067U 26. 9 S-1749	1064C 15. 2 S-364	1078T 17. 4 S-734	6.3
REPEAT EXPOSR .37KBQ	1025B 8.3 18 E-3713	1029U 8.1 18 E-3571	1035A 7.9 19 E-4372	1046T 3.1 2 D-364	1046B 7.5 18 D-3033	1057S 7.9 18 E-3463	1057A 12. 20 E-4140	1067T 11. 20 D-4282	1051A 11. 18 E-3589	1071S 7.9 19 E-4226	1066A 11. 20 D-4294	1076S 8.0 20 E-3624	0.52
REPEAT EXPOSR .37KBQ	1027B 6.0 12 D-2125	1035U 6.8 16 E-4134	1037B 8.9 20 E-3643	1051S 12. 19 E-3617	1041B 8.9 19 E-3377	1057T 8.3 20 D-4444	1054B 9.6 17 E-3205	1055S 13. 19 E-3533	1056C 7.8 20 D-4253	1070U 6.4 14 E-2450	1065B 10. 19 E-3927	1073U 7.6 12 D-1933	0.52
CONTROL	1037E 0 18 E-5080	1044T 0 18 E-5860	1040A 0 13 D-2250	1051T 0 18 D-4208	1043A 0 18 E-3941	1058S 0 18 E-5644	1058A 0 18 E-5364	1066T 0 18 A-5805	1062A 0 6 D-969	1068V 0 18 E-4383	1062C 0 18 D-5050	1077T 0 18 E-4732	0
	1028A 5.6 1 E-4072	=ANIMAL NUMBER =TOTAL EXPOSURE TO DATE (KBQ) =NUMBER OF EXPOSURE (INCLUDING SHAM EXPOSURES) =A=ALIVE, D=DEAD, E=EUTHANIZED, S=SACRIFICED DAYS AFTER INITIAL EXPOSURE AT DEATH OR ON 9-30-93											

Figure 16. Experimental design for the longevity study of Beagle dogs exposed repeatedly by inhalation to 0.75 μm AMAD aerosols of $^{239}PuO_2$ (Status as of 9-30-93).

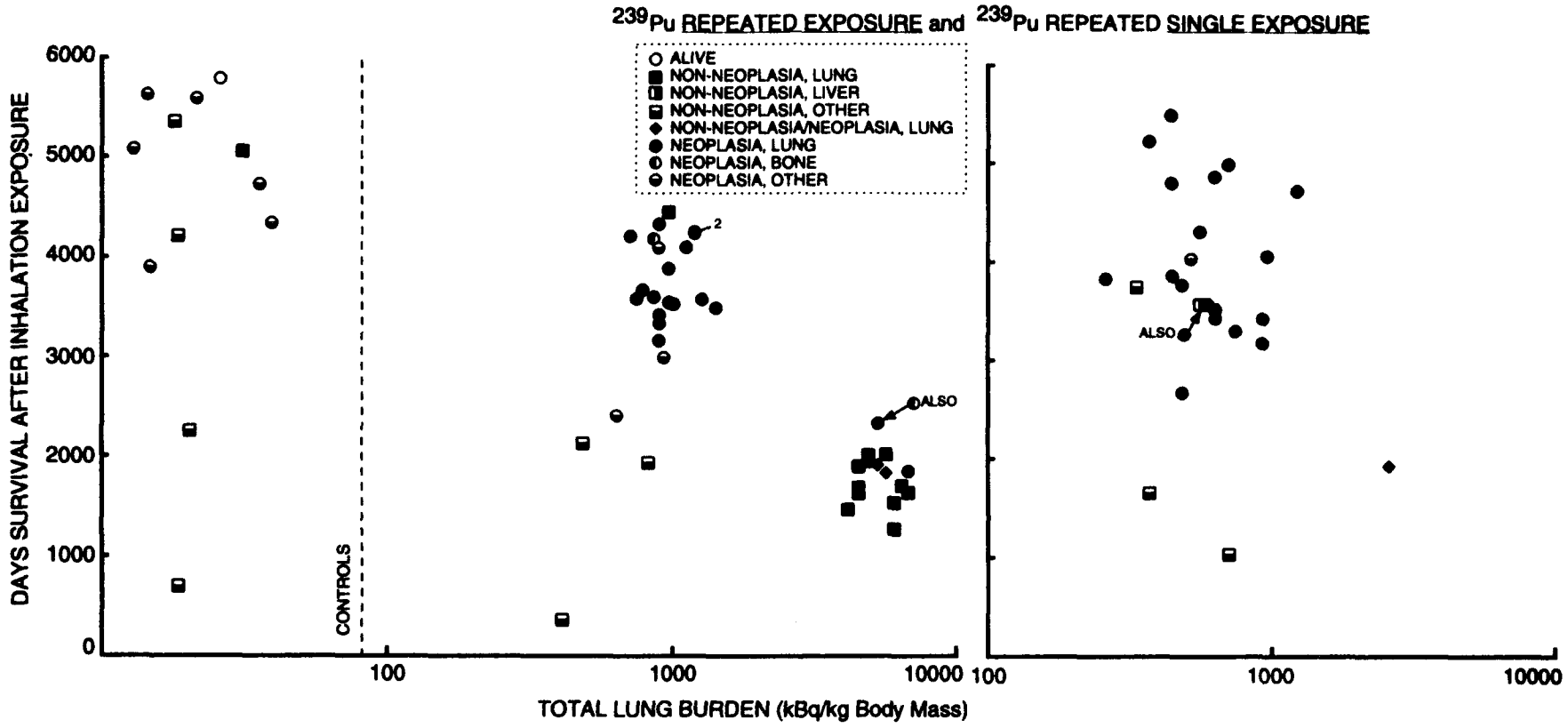


Figure 17. Survival of dogs exposed semiannually by inhalation to monodisperse aerosols of $^{239}PuO_2$ (Status as of 9-30-93).

Table 9

Summary of Major Findings at Death in Dogs Repeatedly Exposed by Inhalation to 0.75 μm Aerodynamic Diameter Monodisperse Aerosols of $^{239}PuO_2$ (Status as of 9-30-93)

	Number of Dogs	TLB[a] (kBq ^{239}Pu/kg Body Weight)	Survival Times (Days after Exposure)	Cumulative Radiation Dose to Lung (Gy)
^{239}Pu-Exposed				
Non-Neoplasia				
Lung	12	0.41-0.68	1267-4444	6.1-27
Bone Marrow	0	--	--	--
Liver	1[b]	0.56	3564	4.0
Other	6	0.33-0.81	364-3740	0.73-4.3
Neoplasia				
Lung Injury with Lung Neoplasia	3	0.50-2.6	1829-1920	15-24
Lung	36[b,c]	0.26-1.4	1892-5517	1.9-31
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	2[c]	0.53,0.85	2374,4226	5.4,30
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	5	0.52-0.93	2450-4134	2.8-5.6
Control				
Non-Neoplasia				
Lung	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	5	--	969-5364	--
Neoplasia				
Lung Injury with Lung Neoplasia	0	--	--	--
Lung	0	--	--	--
Nasal Epithelium	0	--	--	--
TBLN	0	--	--	--
Heart	0	--	--	--
Bone	0	--	--	--
Bone Marrow	0	--	--	--
Liver	0	--	--	--
Other	6	--	3941-5660	--

[a]TLB=Total lung burdens based on whole-body counting of ^{169}Yb.
[b]One dog had a lung tumor and hepatic degeneration.
[c]One dog had lung and bone tumors.

Dog 1067B, a male with an ILB of 0.44 kBq ^{239}Pu/kg body weight, was found dead 5517 days after a single inhalation exposure. The dog had a long history of prostatitis, prostamegaly, and calcified prostatic cysts. At necropsy, pulmonary edema was found to be the immediate cause of death. The principal cause of death was a pulmonary adenocarcinoma widely disseminated through the lung with metastasis to the local lymph nodes. Other neoplasms, which did not contribute to the clinical condition, included a leiomyoma of the esophagus, a follicular carcinoma of the thyroid, a follicular adenoma of the thyroid, and an adenoma of the adrenal cortex.

Dog 1050A, a male with an ILB of 0.37 kBq ^{239}Pu/kg body weight, was euthanized with a lung carcinoma 5258 days after a single initial inhalation exposure. Thirty months before death a lung carcinoma was diagnosed during routine clinical examination. The tumor gradually enlarged, but caused no clinical signs until 2 wk before euthanasia. At that time, hypertrophic pulmonary osteopathy was diagnosed. Shortly later, coughing developed, and euthanasia was recommended.

At necropsy, the principal alterations were a primary bronchioloalveolar carcinoma and secondary pulmonary hypertrophic osteopathy. In the lungs, there were one or several primaries and multiple intrapulmonic metastases. The neoplasm had not metastasized out of the lungs but was responsible for the osteopathy. A perifollicular cell adenoma of the thyroid was also found but was incidental.

Dog 1044T, a female control, was euthanized with a recurring subcutaneous tumor 5660 days after exposure. The mass was first noted caudal to the shoulder 21 mo before death. The mass was surgically removed and diagnosed as a myxosarcoma. Nine months later, it was removed a second time. Six months before death, the myxosarcoma recurred for the third time. Because of the multiple recurrence and poor clinical condition, the dog was euthanized.

At necropsy, the myxosarcoma was found to be extensively invasive locally but had not metastasized. Numerous aging lesions were found that did not contribute to the clinical condition including a parathyroid gland adenoma, a vaginal fibroma, and mammary adenoma.

Dog 1058A, a male control, was euthanized in renal failure 5364 days after initial inhalation exposure. The dog had a long history of clinical problems, including marked spondylosis, marked prostatomegaly with chronic prostatitis, right heart enlargement with a grade IV systolic murmur, and chronic renal disease.

At necropsy, the principal lesions were in the kidney and included chronic nephropathy and those of renal secondary hyperparathyroidism; bilateral parathyroid hyperplasia, fibrous osteodystrophy, and bone marrow atrophy. Several spontaneous, incidental neoplasms were noted: parathyroid adenoma, thyroid follicular cell adenoma, adrenocortical adenoma, sebaceous adenoma of skin, and interstitial cell adenoma of testes.

Dog 1058S, a female control, was euthanized with metastatic carcinoma 5644 days after exposure. The dog had a history of multiple mammary masses, cardiomegaly, and intervertebral disc disease. Five days before euthanasia, she had peritoneal and pleural effusions and palpable abdominal mass.

At necropsy, an undifferentiated acinar cell carcinoma of the pancreas was found with widespread metastases. Metastatic neoplasms in the liver had destroyed large areas of hepatic parenchyma. Other, smaller, metastases were present in the mesenteries, omentum, mediastinum, lungs, and multiple lymph nodes.

3. Annual Report References to Dog Longevity Studies in which All Dogs Have Died

It is our custom to provide an annual status report on each dog longevity study in which dogs are still alive. These reports provide historical perspective on each study and on the sequence in which different events occurred. When all dogs in a given study are dead, the scientific effort in that study is directed to final histopathological reviews, data analyses, dose-response modeling, and open literature publications.

Recognizing that annual progress reports for an individual study may span about 20 yr, it is desirable to provide the interested reader with a guide to past annual reports and their contents. In the material that follows, a graph that illustrates the relationship between long-term retained radionuclide burden, survival time, and prominent pathological observations at death is presented for each study in which all dogs are dead. This graph is followed by an annotated list of all annual report references for that particular study.

a. $^{90}SrCl_2$ Longevity and Sacrifice Studies

Figure 18 provides data on long-term retained burden and survival time for Beagle dogs that inhaled $^{90}SrCl_2$, and Table 10 presents annual report references to these dogs.

b. $^{144}CeCl_3$ Longevity Study

Table 11 presents annual report references to Beagle dogs that inhaled $^{144}CeCl_3$, and Figure 19 provides data on the long-term retained burden and survival time for these dogs.

c. $^{91}YCl_3$ Longevity Study

Figure 20 provides data on the long-term retained burden and survival time on Beagle dogs that inhaled $^{91}YCl_3$, and Table 12 presents annual report references on these dogs.

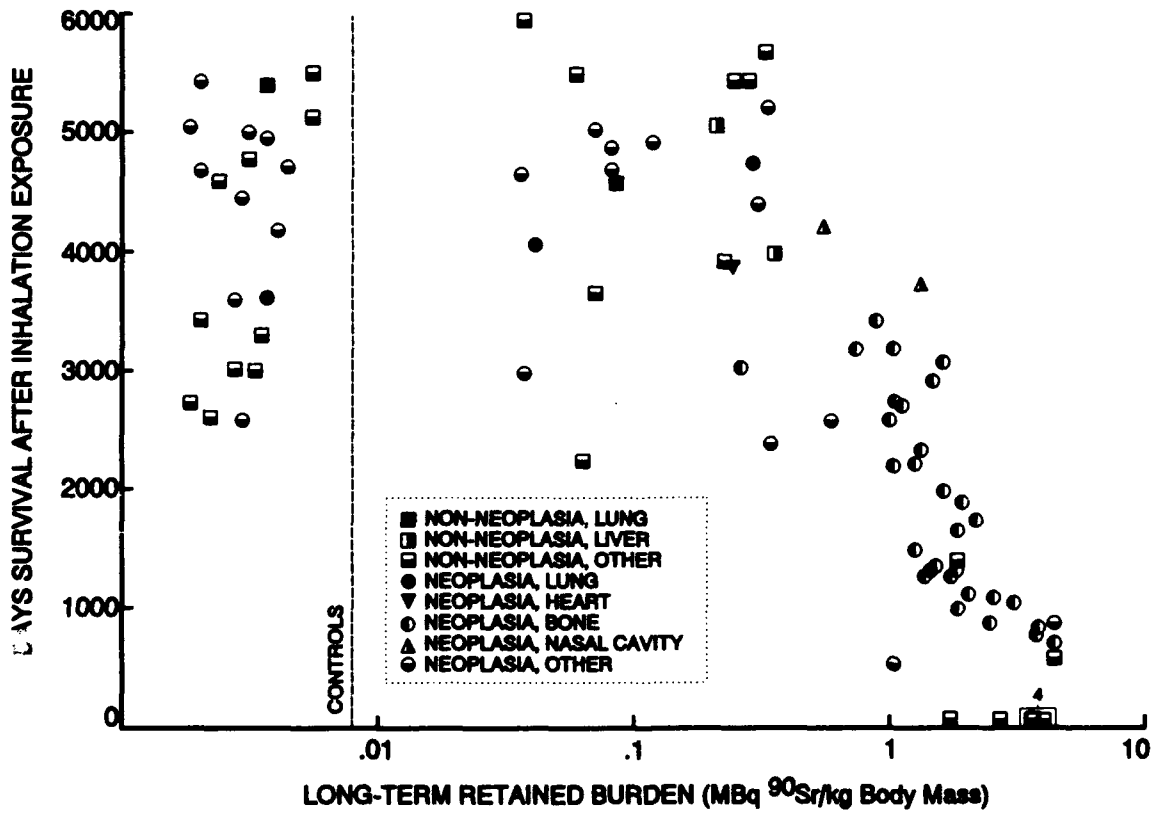


Figure 18. Relationship between long-term retained burden and survival time for Beagle dogs that inhaled $^{90}SrCl_2$.

Table 10

Annual Report References to Longevity and Sacrifice Studies Involving Beagle Dogs that Inhaled $^{90}SrCl_2$

Report No.	Year and Document No.	Pages	Major Contents
I.	1966-67, LF-38	1-18	Exposure details; whole-body retention; ^{85}Sr deposition and fate; dosimetry methodology; early clinical findings, hematology, serum chemistry, microbiology, and pathology in early post-exposure period.
II.	1967-68, LF-39	1-13	Whole-body retention summary; dosimetry; and clinical observations, hematology, and pathology.
III.	1968-69, LF-41	1-7	Whole-body retention; biological effects summary; and survival curves.
IV.	1969-70, LF-43	123-127	Annual status report.
V.	1970-71, LF-44	121-125	Annual status report.
VI.	1971-72, LF-45	129-136	Annual status report, comparison with ^{90}Sr citrate study at the University of Utah.
VII.	1972-73, LF-46	86-90	Annual status report.
VIII.	1973,74, LF-49	89-92	Annual status report.
IX.	1974-75, LF-52	134-138	Annual status report.
X.	1975-76, LF-56	154-157	Annual status report.
XI.	1976-77, LF-58	62-65	Annual status report.
XII.	1977-78, LF-60	68-71	Annual status report.
XIII.	1978-79, LF-69	57-61	Annual status report.
XIV.	1979-80, LMF-84	48-52	Annual status report.
XV.	1980-81, LMF-91	67-72	Annual status report.
XVI.	1981-82, LMF-102	271-275	Final status report.
XVII.	1982-83, LMF-107	183-189	Bone cancer risk estimates.
XVIII.	1983-84, LMF-113	154-158	Study summary.
	1984-85, LMF-114	175-180	Analysis of early hematological effects.
	1984-85, LMF-114	275-279	Logistic analysis of dose-effects data.
	1985-86, LMF-115	167-176	Analysis of late biological effects.
	1988-89, LMF-128	63-65	Effects of route of exposure and dose rate on bone cancers.
	1990-91, LMF-135	82-84	Alpha- vs. beta-induced bone cancers.
	This report	57-59	Life-span health effects.
	This report	60-61	Bone tumor incidence.
	This report	62-65	Lung tumors in control dogs.

Table 11

Annual Report References to the Longevity Study Involving Beagle Dogs that Inhaled $^{144}CeCl_3$

Report No.	Year and Document No.	Pages	Major Contents
I.	1966-67, LF-38	19-39	Exposure details; whole-body retention; deposition and fate in parallel serial sacrifice study; dosimetry methodology; clinical findings, hematology, clinical chemistry, microbiology, and pathology in early post-exposure period.
II.	1967-68, LF-39	14-25	Deposition and fate in parallel serial sacrifice study; dosimetry; and clinical findings, hematology, and pathology.
III.	1968-69, LF-41	8-14	Whole-body retention, biological effects summary.
IV.	1969-70, LF-43	128-136	Fate and dosimetry, biological effects summary.
V.	1970-71, LF-44	126-135	Whole-body retention, tissue distribution, clinical findings and pathology.
VI.	1971-72, LF-45	137-139	Annual status report.
VII.	1972-73, LF-46	91-95	Dosimetry methodology, annual status report.
VIII.	1973-74, LF-49	93-97	Annual status report.
IX.	1974-75, LF-52	139-142	Annual status report.
X.	1975-76, LF-56	158-163	Annual status report.
XI.	1976-77, LF-58	69-73	Annual status report.
XII.	1977-78, LF-60	76-79	Annual status report.
XIII.	1978-79, LF-69	66-70	Annual status report.
XIV.	1979-80, LMF-84	57-61	Annual status report.
XV.	1980-81, LMF-91	79-83	Annual status report.
XVI.	1981-82, LMF-102	280-283	Annual status report.
XVII.	1982-83, LMF-107	194-197	Annual status report.
XVIII.	1983-84, LMF-113	163-167	Final status report, preliminary cancer risk estimates.
	1984-85, LMF-115	247-250	Nonstochastic effects; nonneoplastic liver disease and tumors in nonirradiated organs.
	1989-90, LMF-130	70-74	Biological effects summary.
	1989-90, LMF-130	75-77	Hepatic tumor comparison.
	This report	57-59	Life-span health effects.
	This report	60-61	Bone tumor incidence.
	This report	62-65	Lung tumors in control dogs.

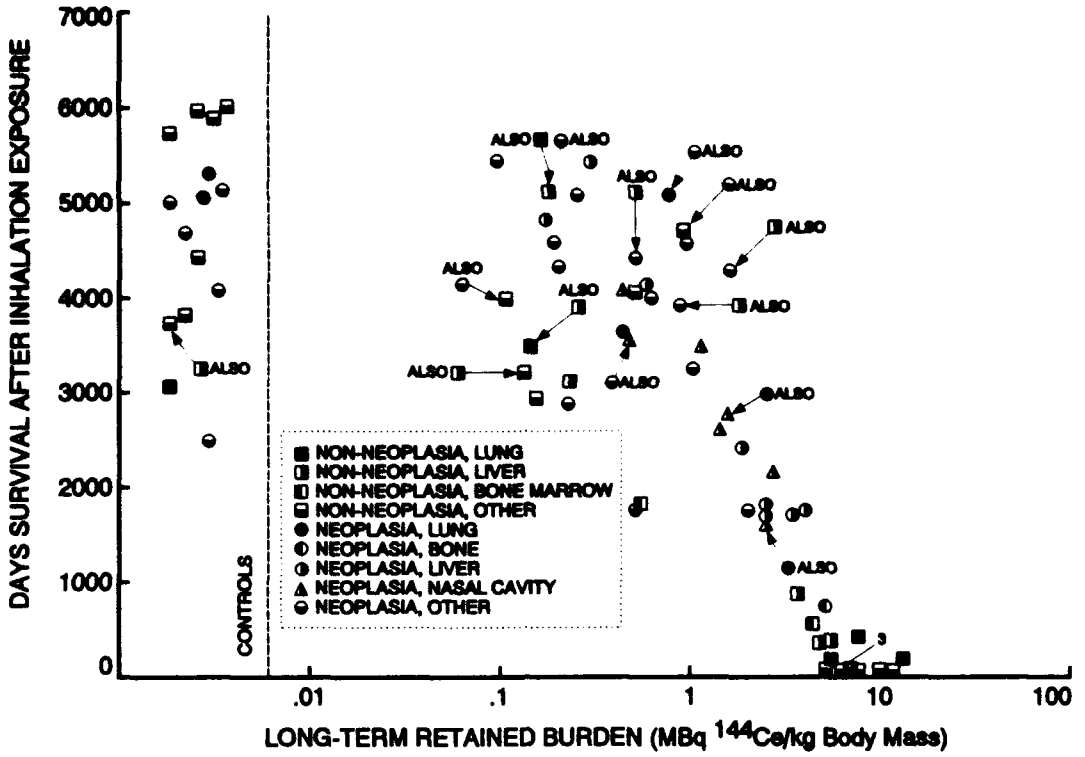


Figure 19. Relationship between long-term retained burden and survival time for Beagle dogs that inhaled $^{144}CeCl_3$.

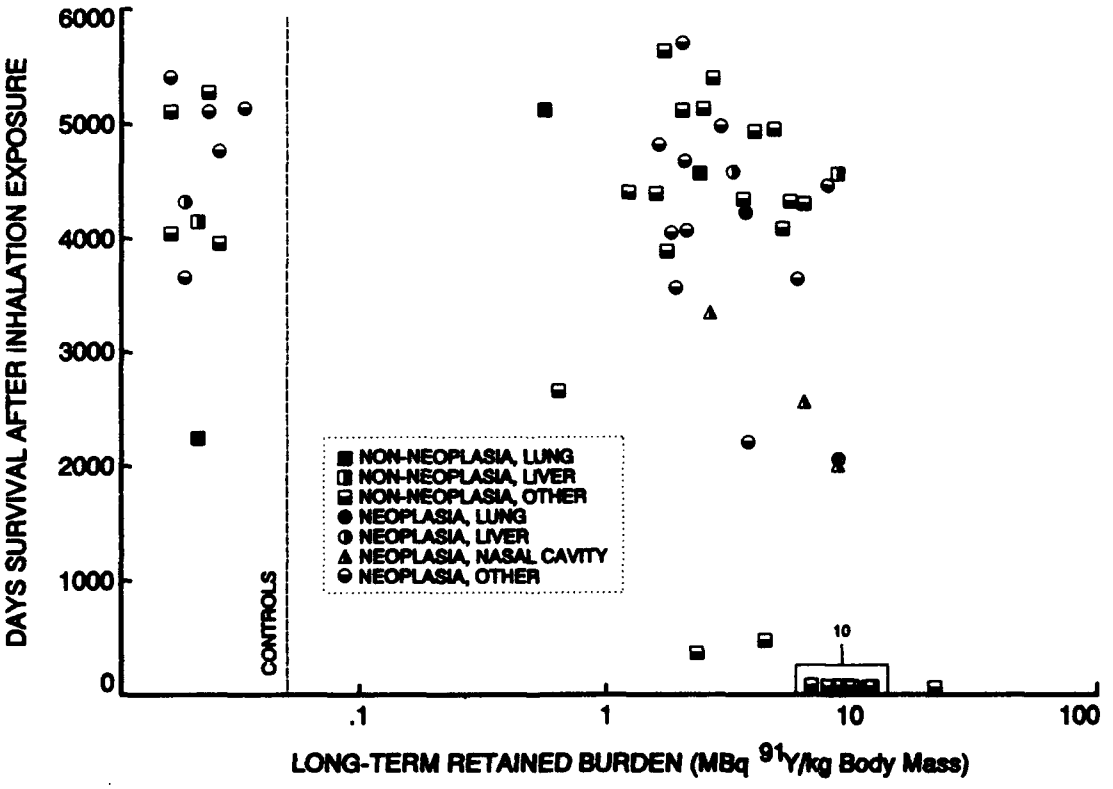


Figure 20. Relationship between long-term retained burden and survival time for Beagle dogs that inhaled $^{91}YCl_3$.

d. $^{137}CsCl$ Longevity Study

Table 13 presents annual report references to Beagle dogs that were injected with $^{137}CsCl$, and Figure 21 provides data on long-term retained burden and survival time for these dogs.

Table 12

Annual Report References to the Longevity Study
Involving Beagle Dogs that Inhaled $^{91}YCl_3$

Report No.	Year and Document No.	Pages	Major Contents
I.	1966-67, LF-38	40-64	Exposure details; whole-body retention; deposition and fate in parallel serial sacrifice study; dosimetry methodology; and clinical observations, hematology, clinical chemistry, microbiology, and pathology in early post-exposure period.
II.	1967-68, LF-39	26-32	Whole-body retention; and clinical observations, hematology, clinical chemistry and pathology.
III.	1968-69, LF-41	15-18	Annual status report.
IV.	1969-70, LF-43	137-139	Annual status report.
V.	1970-71, LF-44	136-138	Annual status report.
VI.	1971-72, LF-45	140-143	Annual status report.
VII.	1972-73, LF-46	96-99	Dosimetry methodology, annual status report.
VIII.	1973-74, LF-49	98-100	Annual status report.
IX.	1974-75, LF-52	143-145	Annual status report.
X.	1975-76, LF-56	164-166	Annual status report.
XI.	1976-77, LF-58	66-68	Annual status report.
XII.	1977-78, LF-60	72-75	Annual status report.
XIII.	1978-79, LF-69	62-65	Annual status report.
XIV.	1979-80, LMF-84	53-56	Annual status report.
XV.	1980-81, LMF-84	73-78	Annual status report.
XVI.	1981-82, LMF-102	276-279	Annual status report.
XVII.	1982-83, LMF-107	190-193	Annual status report.
XVIII.	1983-84, LMF-113	159-162	Final status report, preliminary cancer risk estimates.
	1990-91, LMF-135	65-67	Biological effects summary.
	This report	57-59	Life-span health effects.
	This report	60-61	Bone tumor incidence.
	This report	62-65	Lung tumors in control dogs.

e. ^{90}Y in FAP Longevity Study

Figure 22 provides data on the relationship between ILB and survival time for dogs that inhaled ^{90}Y in FAP, and Table 14 presents annual report references to these dogs.

f. ^{91}Y in FAP Longevity Study

Table 15 presents annual report references to Beagle dogs that inhaled ^{91}Y in FAP, and Figure 23 provides data on the long-term burden and survival time of these dogs.

Table 13

Annual Report References to Longevity and Sacrifice Studies
Involving Beagle Dogs that were Injected Intravenously with $^{137}CsCl$

Report No.	Year and Document No.	Pages	Major Contents
I.	1967-68, LF-39	54-75	Experimental design; injection details; whole-body retention; urinary and fecal excretion; tissue concentrations; dosimetry details; and early clinical findings, hematology, serum chemistry, and pathology in early post-exposure period.
II.	1968-69, LF-41	36-45	Whole-body retention; dosimetry; microbiology; immunology; hematology; and clinical findings, biochemistry, and pathology.
III.	1969-70, LF-43	140-145	Dosimetry, biological effects summary.
IV.	1970-71, LF-44	139-144	Whole-body retention, biological effects summary.
V.	1971-72, LF-45	144-146	Annual status report.
VI.	1972-73, LF-46	100-102	Annual status report.
VII.	1973-74, LF-49	101-103	Annual status report.
VIII.	1974-75, LF-52	146-149	Annual status report.
IX.	1975-76, LF-56	167-171	Annual status report.
X.	1976-77, LF-58	74-77	Annual status report.
XI.	1977-78, LF-60	80-83	Annual status report.
XII.	1978-79, LF-69	71-74	Annual status report.
XIII.	1979-80, LMF-84	62-66	Annual status report.
XIV.	1980-81, LMF-91	84-89	Annual status report.
XV.	1981-82, LMF-102	284-288	Annual status report.
XVI.	1982-83, LMF-107	198-202	Annual status report.
XVII.	1983-84, LMF-113	168-171	Annual status report.
XVIII.	1984-85, LMF-114	181-184	Final status report.
	1989-90, LMF-130	66-69	Biological effects summary.
	This report	57-59	Life-span health effects.
	This report	60-61	Bone tumor incidence.
	This report	62-65	Lung tumors in control dogs.

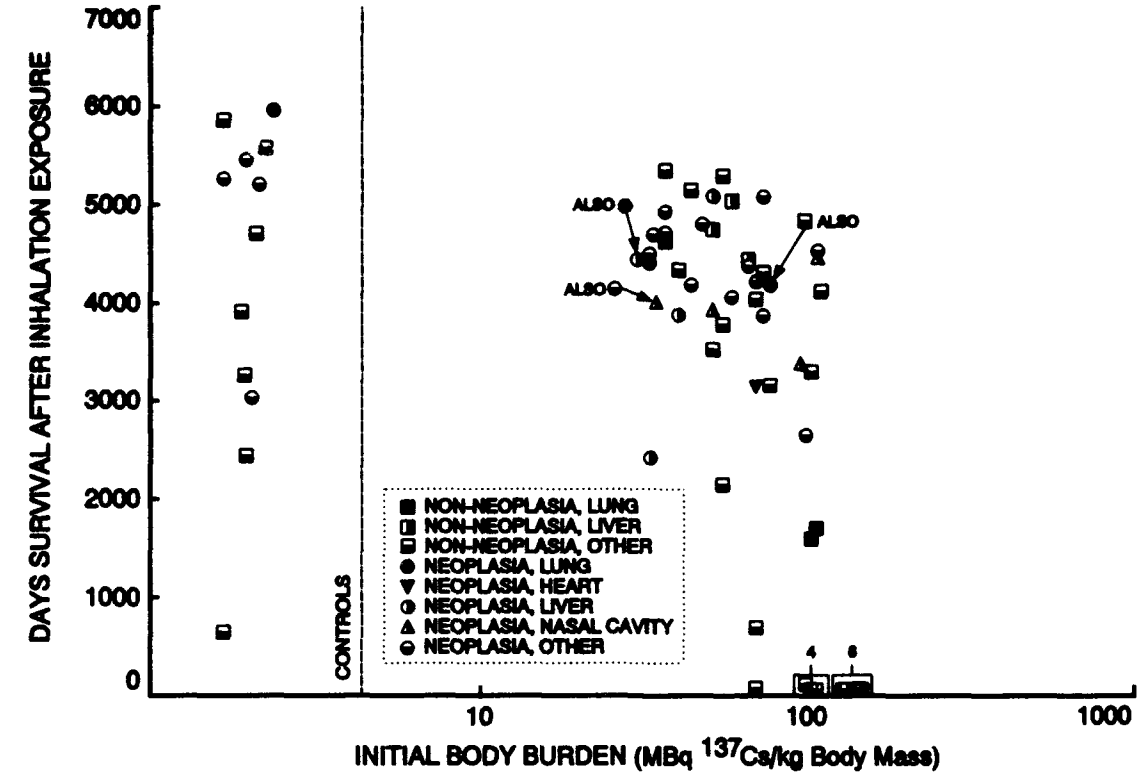


Figure 21. Relationship between long-term retained burden and survival time for dogs that were injected intravenously with $^{137}CsCl$.

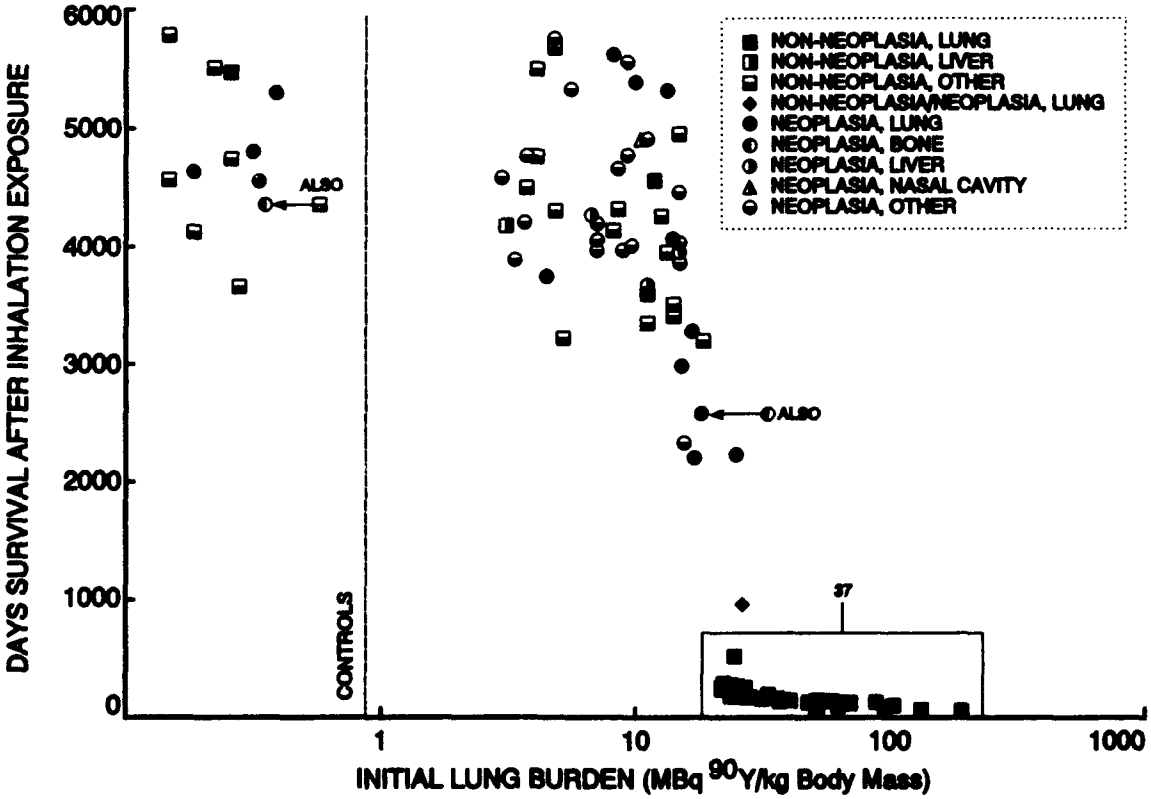


Figure 22. Relationship between ILB of ^{90}Y and survival time for dogs that inhaled ^{90}Y in fused aluminosilicate particles.

g. ^{144}Ce in FAP Longevity Study

Figure 24 provides data on the long-term burden and survival time for Beagle dogs that inhaled ^{144}Ce in FAP, and Table 16 presents annual report references to these dogs.

Table 14

Annual Report References to Longevity and Sacrifice Series
Involving Beagle Dogs that Inhaled ^{90}Y in FAP

Report No.	Year and Document No.	Pages	Major Contents
I.	1968-69, LF-41	46-58	Experimental procedures; whole-body retention; excretion; tissue distribution; dosimetry; and clinical observations, hematology, pulmonary function, clinical chemistry, and pathology.
II.	1969-70, LF-43	146-162	Experimental procedures; experimental design (8 blocks); tissue distribution; and clinical observations, microbiology, and pathology.
III.	1970-71, LF-44	145-150	Full experimental design, dosimetry summary, and biological effects summary.
IV.	1971-72, LF-45	147-150	Annual status report.
V.	1972-73, LF-46	103-107	Annual status report.
VI.	1973-74, LF-49	104-107	Annual status report.
VII.	1974-75, LF-52	150-153	Annual status report.
VIII.	1975-76, LF-56	172-175	Annual status report.
IX.	1976-77, LF-58	78-82	Annual status report.
X.	1977-78, LF-60	84-88	Annual status report.
XI.	1978-79, LF-69	75-78	Annual status report.
XII.	1979-80, LMF-84	67-70	Annual status report.
XIII.	1980-81, LMF-91	90-95	Annual status report.
XIV.	1981-82, LMF-102	289-294	Annual status report.
XV.	1982-83, LMF-107	203-207	Annual status report.
XVI.	1983-84, LMF-113	172-176	Annual status report.
XVII.	1984-85, LMF-114	185-190	Annual status report.
XVIII.	1985-86, LMF-115	177-181	Annual status report.
XIX.	1986-87, LMF-120	205-208	Final status report.
	1986-87, LMF-120	196-204	Preliminary lung cancer risk estimates.
	1989-90, LMF-130	78-81	Beta dose-rate effects in lung.
	This report	62-65	Lung tumors in control dogs.

Table 15

Annual Report References to Longevity and Sacrifice Series
Involving Beagle Dogs that Inhaled ^{91}Y in FAP

Report No.	Year and Document No.	Pages	Major Contents
I.	1969-70, LF-43	163-182	Exposure details; whole-body retention; deposition and fate in parallel serial sacrifice study; excretion in urine and feces; dosimetry methodology; experimental design (4 blocks); and clinical observations, hematology, pulmonary physiology, clinical chemistry, and pathology in early post-exposure period.
II.	1970-71, LF-44	151-163	Full experimental design; initial deposition; whole-body retention; tissue distribution; dosimetry; and clinical observations; hematology, clinical chemistry, pulmonary function, and pathology for early post-exposure period.
III.	1971-72, LF-45	151-156	Biological effects summary.
IV.	1972-73, LF-46	108-111	Annual status report.
V.	1973-74, LF-49	108-112	Annual status report.
VI.	1974-75, LF-52	154-159	Annual status report.
VII.	1975-76, LF-56	176-179	Annual status report.
VIII.	1976-77, LF-58	83-86	Annual status report.
IX.	1977-78, LF-60	89-93	Annual status report.
X.	1978-79, LF-69	79-82	Annual status report.
XI.	1979-80, LMF-84	71-75	Annual status report.
XII.	1980-81, LMF-91	96-100	Annual status report.
XIII.	1981-82, LMF-102	295-299	Annual status report.
XIV.	1982-83, LMF-107	208-212	Annual status report.
XV.	1983-84, LMF-113	177-181	Annual status report.
XVI.	1984-85, LMF-114	191-195	Annual status report.
XVII.	1985-86, LMF-115	182-186	Annual status report.
XVIII.	1986-87, LMF-120	209-212	Final status report.
	1986-87, LMF-120	196-204	Preliminary lung cancer risk estimates.
	1989-90, LMF-130	78-81	Beta dose-rate effects in lung.
	1990-91, LMF-135	61-64	Biological effects summary.
	1990-91, LMF-135	79-82	Alpha- vs. beta-induced lung cancer.
	This report	62-65	Lung tumors in control dogs.

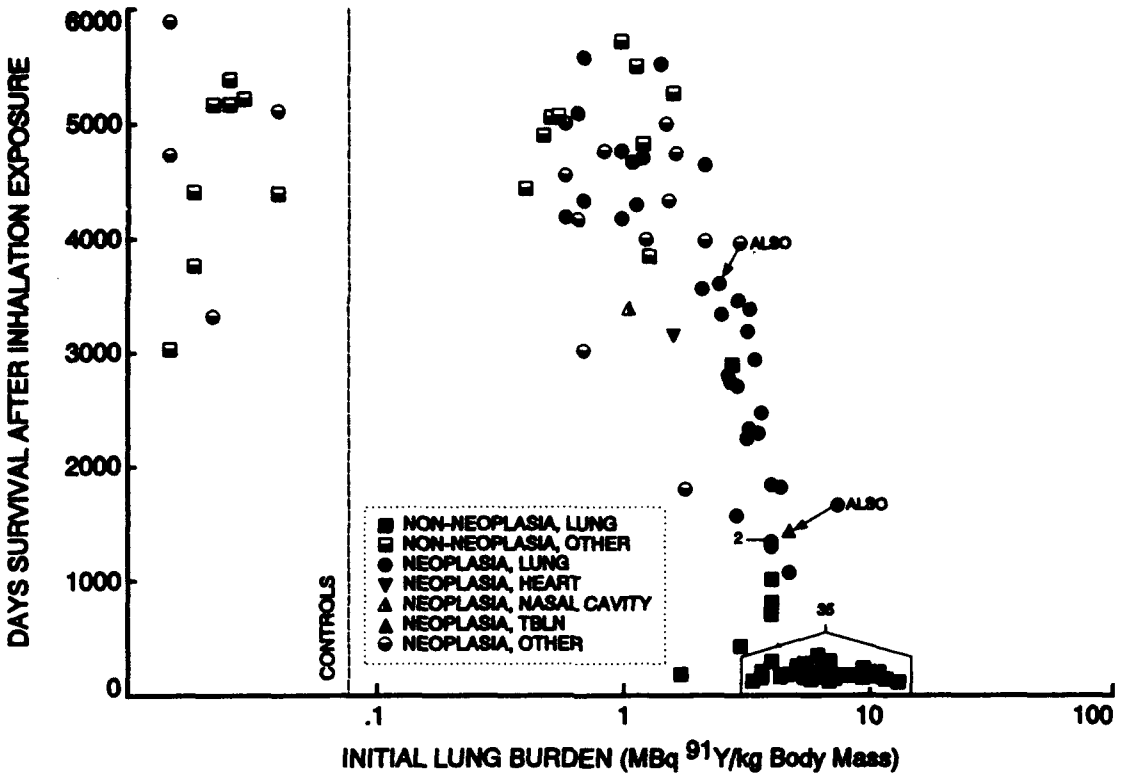


Figure 23. Relationship between ILB of ^{91}Y and survival time for dogs that inhaled ^{91}Y in fused aluminosilicate particles.

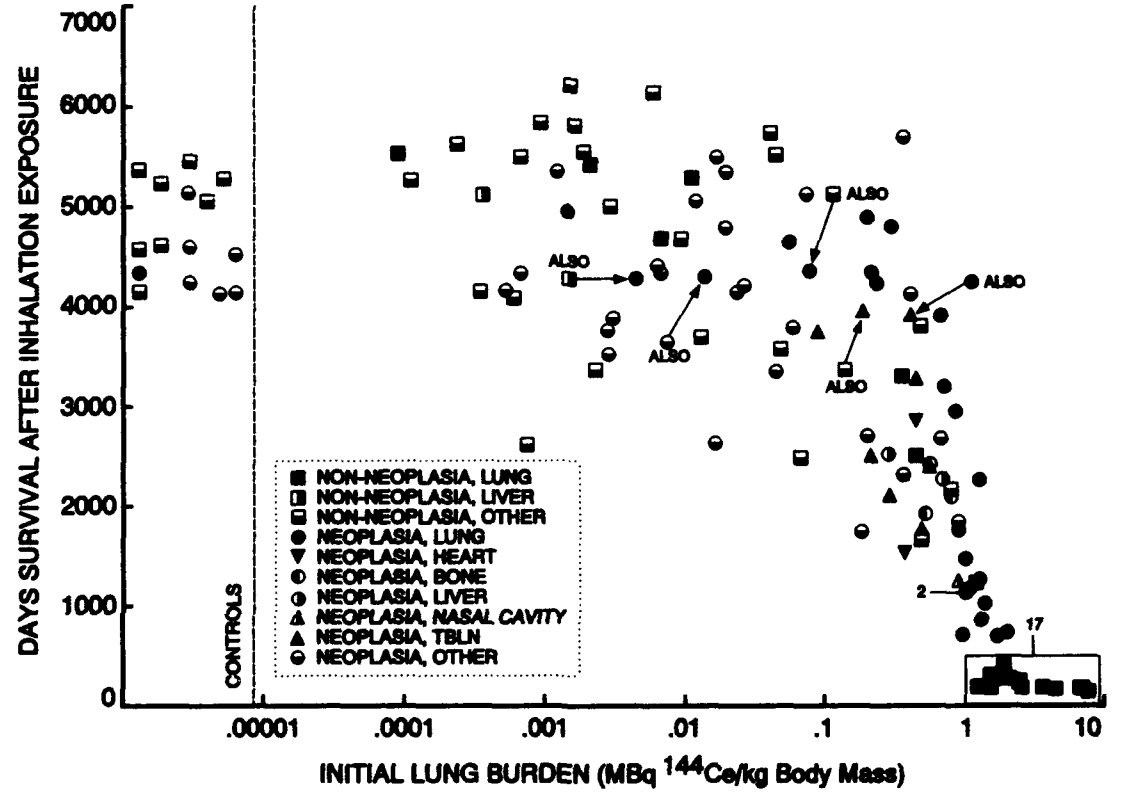


Figure 24. Relationship between ILB of ^{144}Ce and survival time for dogs that inhaled ^{144}Ce in fused aluminosilicate particles.

Table 16

Annual Report References to Longevity and Sacrifice Series Involving Beagle Dogs that Inhaled ^{144}Ce in FAP

Report No.	Year and Document No.	Pages	Major Contents
I.	1967-68, LF-39	33-53	Exposure details; whole-body retention; deposition and fate in parallel serial sacrifice study and dogs dying in early post-exposure period; and clinical observations, hematology, pulmonary physiology, clinical chemistry, and pathology in early post-exposure period.
II.	1968-69, LF-41	19-35	Partial experimental design; whole-body retention; tissue distribution and retention; dosimetry; and clinical observations, pulmonary function, clinical chemistry, hematology, immunology and pathology.
III.	1969-70, LF-43	183-187	Metabolism and dosimetry; and biological effects summary.
IV.	1970-71, LF-44	164-180	Full experimental designs for Series I and II; tissue distribution and retention; clinical observations; and pathology.
V.	1971-72, LF-45	157-166	Annual status report.
VI.	1972-73, LF-46	112-115	Annual status report.
VII.	1973-74, LF-49	113-117	Annual status report.
VIII.	1974-75, LF-52	160-164	Annual status report.
IX.	1975-76, LF-56	180-185	Annual status report.
X.	1976-77, LF-58	87-92	Annual status report.
XI.	1977-78, LF-60	94-98	Annual status report.
XII.	1978-79, LF-69	83-91	Annual status report.
XIII.	1979-80, LMF-84	76-81	Annual status report.
XIV.	1980-81, LMF-91	101-108	Annual status report.
XV.	1981-82, LMF-102	300-305	Annual status report.
XVI.	1982-83, LMF-107	213-219	Annual status report.
XVII.	1983-84, LMF-113	182-187	Annual status report.
XVIII.	1984-85, LMF-114	196-201	Annual status report.
XIX.	1985-86, LMF-115	187-192	Annual status report.
XX.	1986-87, LMF-120	213-216	Annual status report.
	1986-87, LMF-120	196-204	Preliminary lung cancer risks.
XXI.	1987-88, LMF-121	157-163	Final status report.
	1988-89, LMF-128	66-68	Age-related early health effects.
	1988-90, LMF-130	78-81	Beta dose-rate effects in lung.
	1990-91, LMF-135	75-78	Interspecies lung cancer risks.
	1990-91, LMF-135	79-82	Alpha- vs. beta-induced lung cancer.
	This report	62-65	Lung tumors in control dogs.

h. ^{144}Ce in FAP, Aged-Dog Longevity Study

Table 17 presents annual report references to aged Beagle dogs that inhaled ^{144}Ce in FAP, and Figure 25 presents data on the ILB and survival time of these dogs.

i. ^{90}Sr in FAP Longevity Study

Figure 26 presents data on the relationship between ILB of ^{90}Sr and survival time for all dogs in this study, and Table 18 presents annual report references to this study.

j. $^{238}PuO_2$ Monodisperse Aerosol Longevity Study - 1.5 and 3.0 μm AMAD Particles

Table 19 presents annual report references to these studies involving dogs that inhaled either monodisperse 1.5 μm or 3.0 μm AMAD particles. Figures 27 and 28 illustrate the relationship between the ILB of $^{238}PuO_2$ and survival time for all dogs in these two studies.

k. $^{239}PuO_2$ Aged-Dog Longevity Study

Figure 29 provides data on the ILB survival time of aged Beagle dogs that inhaled $^{239}PuO_2$, and Table 20 presents annual report references to these dogs.

Table 17

Annual Report References to the Longevity Study
Involving Aged Beagle Dogs that Inhaled ^{144}Ce in FAP

Report No.	Year and Document No.	Pages	Major Contents
I.	1971-72, LF-45	172-176	Experimental design (6 blocks); exposure details; dosimetry; and early biological results.
II.	1972-73, LF-46	122-127	Comparison of tissue distribution and biological effects with those in young-adult dogs; summary of early biological results; and annual status report.
III.	1973-74, LF-49	122-125	Annual status report.
IV.	1974-75, LF-52	169-172	Complete experimental design, annual status report.
V.	1975-76, LF-56	190-194	Annual status report.
VI.	1976-77, LF-58	97-101	Annual status report.
VII.	1977-78, LF-60	94-98	Annual status report.
VIII.	1978-79, LF-69	96-100	Annual status report.
IX.	1979-80, LMF-84	86-89	Annual status report.
X.	1980-81, LMF-91	113-116	Annual status report.
XI.	1981-82, LMF-102	310-313	Annual status report.
XII.	1982-83, LMF-107	224-227	Final status report.
XIII.	1983-84, LMF-113	193-195	Study summary.
	1988-89, LMF-128	66-68	Age-related early health effects.

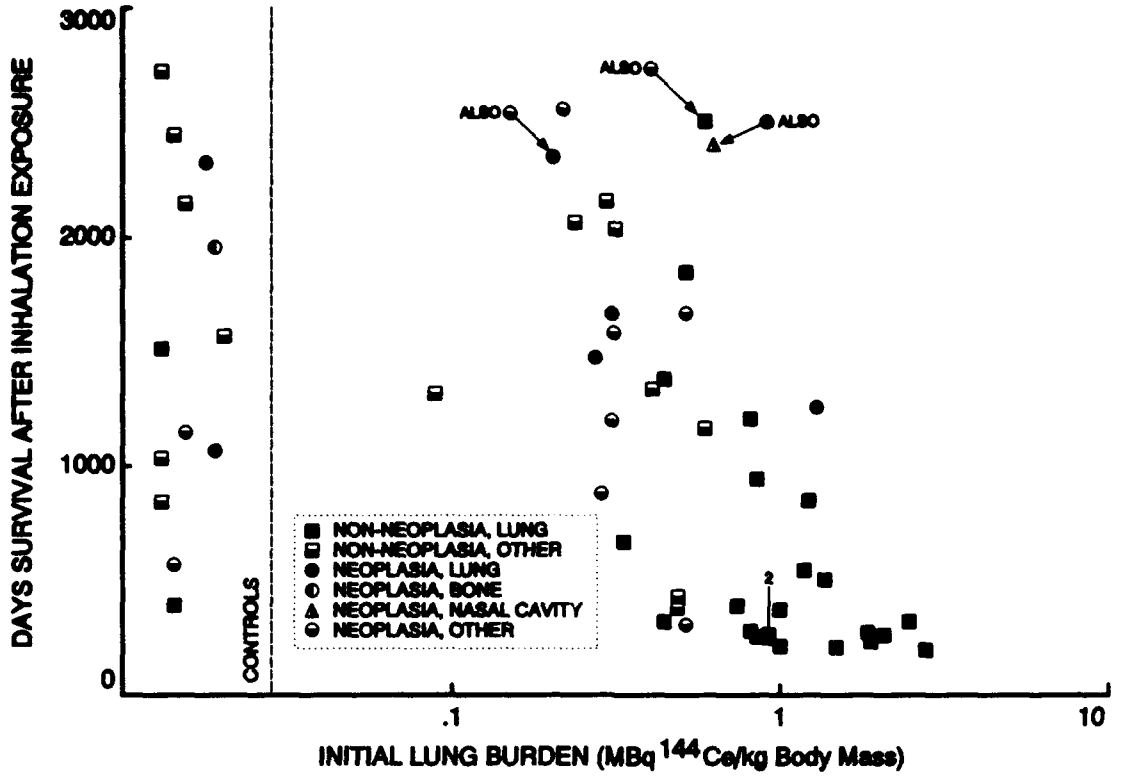


Figure 25. Relationship between ILB of ^{144}Ce and survival time for aged dogs that inhaled ^{144}Ce in fused aluminosilicate particles.

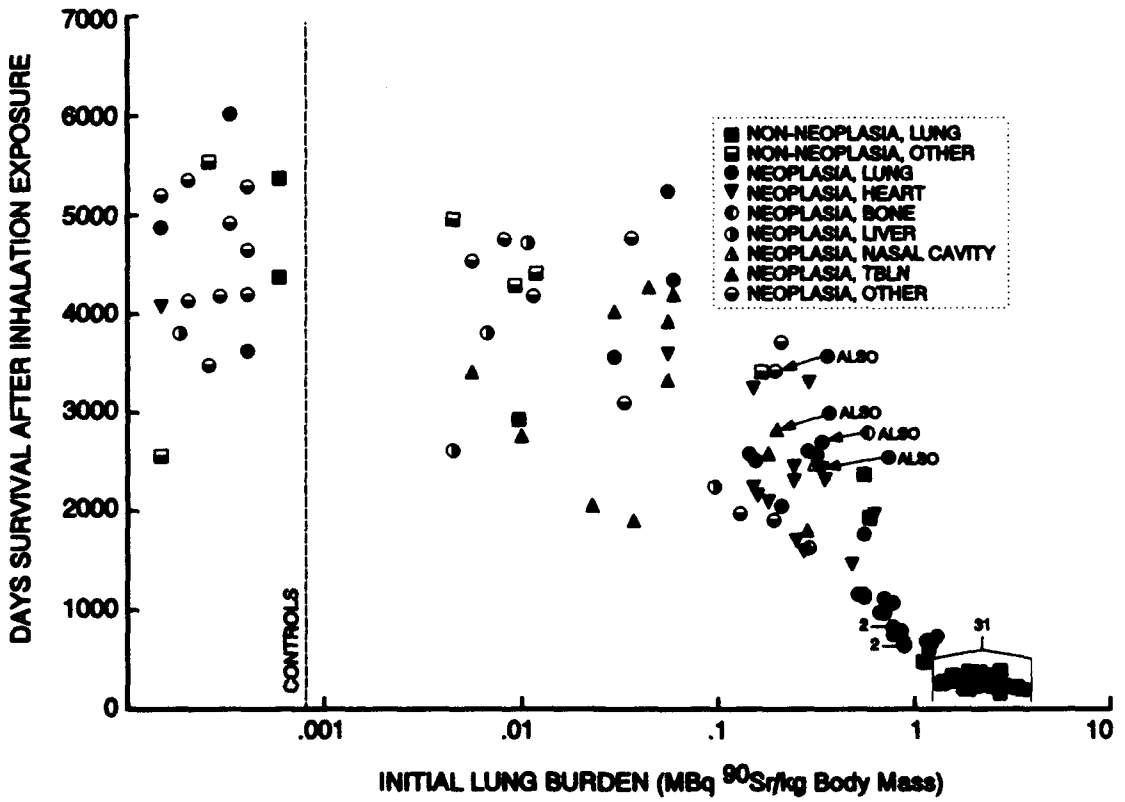


Figure 26. Relationship between ILB of ^{90}Sr and survival time for Beagle dogs that inhaled ^{90}Sr in a fused aluminosilicate matrix.

Table 18

Annual Report References to Longevity and Sacrifice Series
Involving Beagle Dogs that Inhaled ^{90}Sr in Fused Aluminosilicate Particles

Report No.	Year and Document No.	Pages	Major Contents
I.	1969-70, LF-43	188-196	Experimental design, exposure details, whole-body retention, tissue distribution, dosimetry calculations, and early biological effects.
II.	1970-71, LF-44	181-192	Metabolism and dosimetry, excretion of ^{90}Sr, clinical and pathology observations in the early post-exposure period.
III.	1971-72, LF-45	177-188	Dosimetry modeling and calculations for first 12 blocks of dogs, clinical and pathology updates.
IV.	1972-73, LF-46	128-136	Dosimetry calculations, clinical and pathology updates.
V.	1973-74, LF-49	126-129	Annual status report.
VI.	1974-75, LF-52	173-177	Annual status report, addition of six blocks at lower levels.
VII.	1975-76, LF-56	195-199	Annual status report.
VIII.	1976-77, LF-58	102-106	Annual status report.
IX.	1977-78, LF-60	108-112	Annual status report.
X.	1978-79, LF-69	101-106	Annual status report.
XI.	1979-80, LMF-84	90-94	Annual status report.
XII.	1980-81, LMF-91	117-121	Annual status report.
XIII.	1981-82, LMF-102	314-318	Annual status report.
XIV.	1982-83, LMF-107	228-231	Annual status report.
XV.	1983-84, LMF-113	196-200	Annual status report.
XVI.	1984-85, LMF-114	207-211	Annual status report.
XVII.	1985-86, LMF-115	198-203	Annual status report.
XVIII.	1986-87, LMF-120	222-227	Annual status report.
	1986-87, LMF-120	196-204	Priliminary lung cancer risks.
XIX.	1987-88, LMF-121	184-188	Annual status report.
XX.	1988-89, LMF-128	14-17	Annual status report.
XXI.	1989-90, LMF-130	12-15	Annual status report.
	1989-90, LMF-130	78-81	Beta dose-rate effects in lung.
XXII.	1990-91, LMF-135	12-15	Final status report.
	1990-91, LMF-135	79-82	Alpha- vs. beta-induced lung cancer.
	This report	62-65	Lung tumors in control dogs

Table 19

Annual Report References to the Longevity Study Involving Beagle Dogs that Inhaled Monodisperse (1.5 μm or 3.0 μm AMAD) Particles of $^{238}PuO_2$

Report No.	Year and Document No.	Pages	Major Contents
I.	1973-74, LF-49	140-144	Experimental design, inhalation exposures, whole-body counting, initial lung burdens and early biological effects.
II.	1974-75, LF-52	198-203	Initial lung burdens and lymphocyte responses.
III.	1975-76, LF-56	229-237	Tissue distribution, clinical results, pathology findings.
IV.	1976-77, LF-58	122-134	Metabolism, dosimetry, hematological effects, pathology observations.
V.	1977-78, LF-60	132-144	Tissue distribution, dosimetry, hematological and pathological effects.
VI.	1978-79, LF-69	122-133	Tissue distribution, dosimetry, biological effects and survival patterns.
VII.	1979-80, LMF-84	118-128	Lung retention, tissue distribution and biological effects.
VIII.	1980-81, LMF-91	150-158	Simulation model for dosimetry, biological effects summary.
IX.	1981-82, LMF-102	327-335	Annual status report.
X.	1982-83, LMF-107	243-251	Annual status report.
XI.	1983-84, LMF-113	216-224	Tissue distribution results and annual status report.
XII.	1984-85, LMF-114	226-235	Annual status report.
XIII.	1985-86, LMF-115	215-223	Annual status report.
XIV.	1986-87, LMF-120	235-247	Annual status report.
XV.	1987-88, LMF-121	196-205	Annual status report.
XVI.	1988-89, LMF-128	18-24	Annual status report.
XVII.	1989-90, LMF-130	16-21	Annual status report.
XVIII.	1990-91, LMF-135	12-15	Final status report.
	This report	60-61	Bone tumor incidence
	This report	62-65	Lung tumors in control dogs
	This report	66-68	Lung tumor growth rate patterns

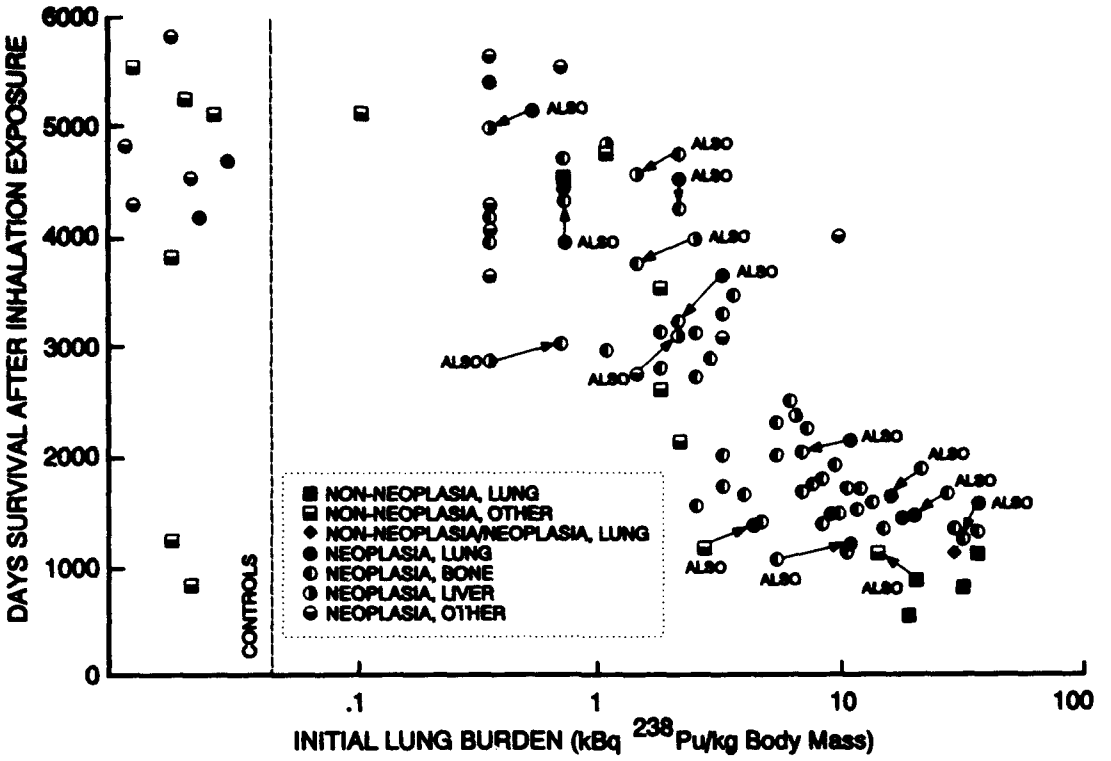


Figure 27. Survival of Beagle dogs that inhaled 1.5 μm AMAD monodisperse aerosols of $^{238}PuO_2$.

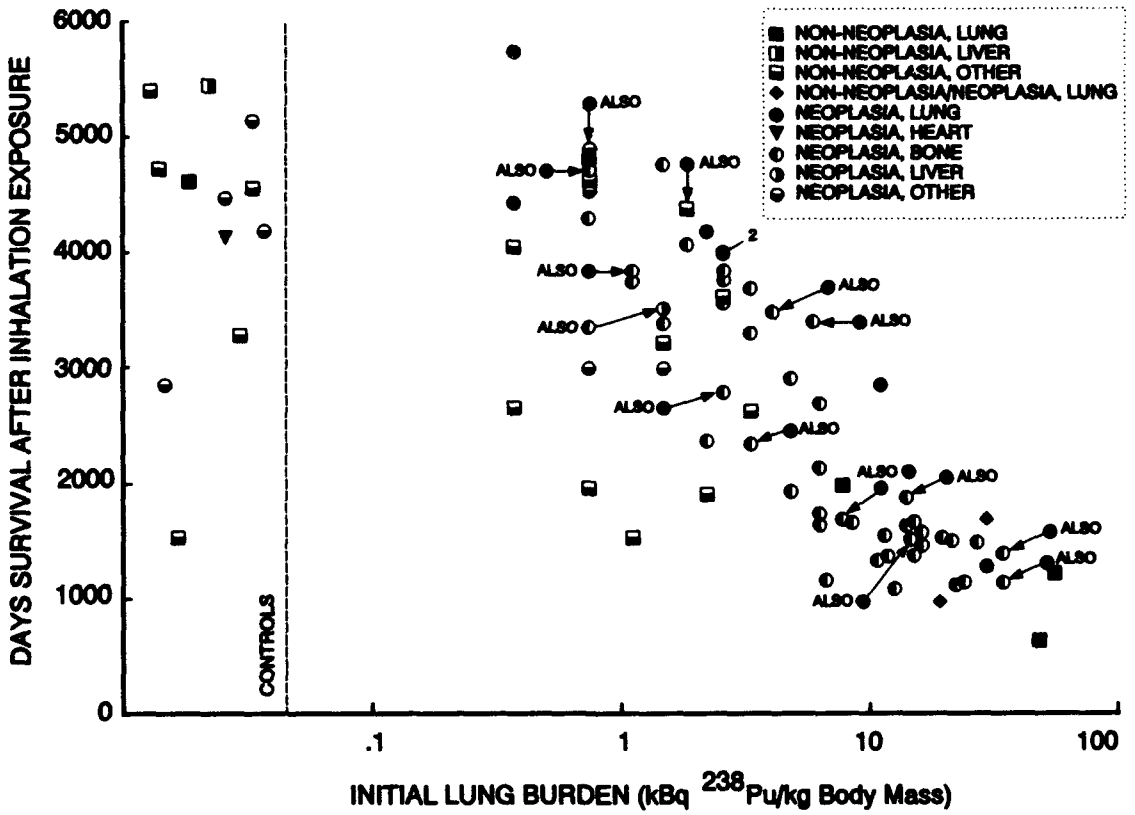


Figure 28. Survival of Beagle dogs that inhaled 3.0 μm AMAD monodisperse aerosols of $^{238}PuO_2$.

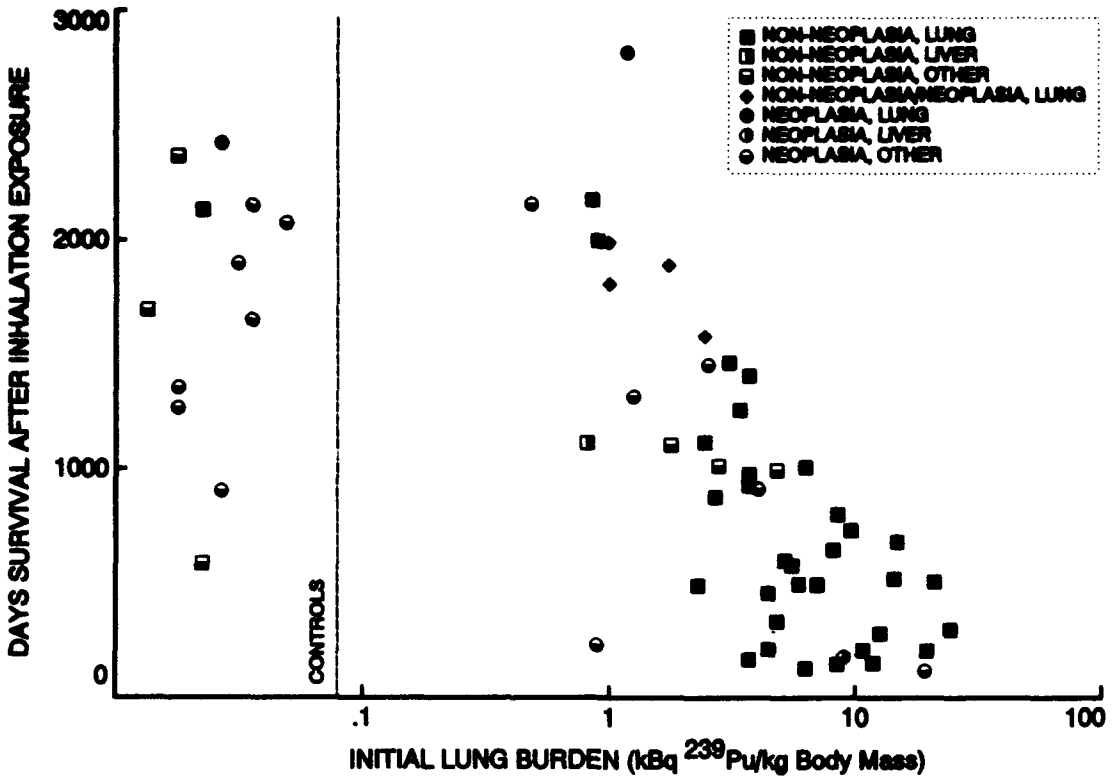


Figure 29. Relationship between ILB of ^{239}Pu and survival time for aged dogs that inhaled $^{239}PuO_2$.

Table 20

Annual Report References to the Longevity Study
Involving Aged Beagle Dogs that Inhaled $^{239}PuO_2$

Report No.	Year and Document No.	Pages	Major Contents
I.	1978-79, LF-45	141-144	Experimental design; initial lung burdens.
II.	1979-80, LMF-84	143-145	Current entries into study, early biological effects.
III.	1980-81, LMF-91	169-173	Annual status report.
IV.	1981-82, LMF-102	347-351	Full experimental design, annual status report.
V.	1982-83, LMF-107	264-268	Annual status report.
VI.	1983-84, LMF-113	237-241	Annual status report.
VII.	1984-85, LMF-114	249-253	Annual status report.
VIII.	1985-86, LMF-115	239-242	Annual status report.
IX.	1986-87, LMF-120	266-270	Annual status report.
X.	1987-88, LMF-121	157-163	Final status report.

D. COMPLETION ACTIVITIES FOR THE ITRI STUDIES

1. Completion of Individual Studies

At the present time, there are 15 ITRI studies in which all dogs have died. These are the studies receiving most of the current efforts directed to study completions. The general strategy being followed for each study is shown in Table 21.

Table 21

General Strategy for Completion of
Individual Life-Span Studies in Dogs at ITRI

- Collect and organize materials and data
- Conduct detailed reviews
  - Dosimetry
  - Clinical
  - Pathology
- Analyze results
- Publish basic manuscripts
  - Dosimetry
  - Biological effects
  - Dose-response modeling
- Prepare cross-cutting risk analyses and manuscripts
  - Among ITRI dog studies
  - Across species including humans
  - With other laboratories
- Send materials to National Radiobiology Archives

A review of the dosimetry, clinical, and pathology materials and records for each dog is necessary to assure uniformity in thoroughness of examination and terminology. Because each life-span study spanned nearly 2 decades, numerous veterinary clinicians and pathologists have been involved. Over such a span of time, individuals, concepts, treatments, terminology, and completeness of diagnosis have changed. Part of the purpose of these reviews is to establish standard terminology, diagnostic criteria, and reporting format. The general approach is for a team comprised of one pathologist, one clinician, and a radiation biologist to review a complete study together. Each individual reviews the appropriate material for their specialty, then all team members agree together on the diagnoses and other findings. The information is then organized on forms and entered into the database.

In the dosimetry portion of this effort, the radiation biologist reviews the performance of the counting equipment, consistency of the standards, and the retention functions for the radionuclide of interest in the various organs of concern. This ensures that the dosimetry is consistent over a study and that changes in counting efficiencies and standards did not affect the results of these long studies. It also ensures that the methods for dose calculations are consistent within each experiment. The dosimetry information is then entered into the dosimetry database.

The clinical materials being reviewed are the medical records, radiographs, hematology data, and clinical chemistry data. The pathologist reviews the written gross necropsy report, biopsy reports, and histopathology and final pathology reports for completeness; reviews the slides for tumors, and determines the organs of major concern; and reviews any photographs of the organs taken at gross necropsy.The clinician and the pathologist discuss each case to establish the following diagnoses: (1) immediate cause of death, (2) primary cause of death, (3) major contributing diseases, and (4) incidental diseases and findings. Under each category, sufficient supporting information is given to demonstrate the basis for the diagnosis. This information is then coded into SNODOG (a modified version of SNOMED) and entered into the database.

Through the end of FY-1993, clinical and pathologic reviews of materials and records have been completed on six studies–$^{90}SrCl_2$, $^{144}CeCl_3$, $^{137}CsCl$, $^{91}YCl_3$, $^{238}PuO_2$ (1.5 μm), and $^{238}PuO_2$ (3.0 μm). These six studies represent an important grouping within the ITRI program because they involved physical or chemical forms that demonstrated the highest degree of *in vivo* radionuclide solubility in the 19 studies conducted. This solubility leads to a range of organs being at risk in addition to the respiratory tract. Most of the ITRI manuscript efforts are being directed to the completion and publication of these studies. These manuscripts will provide valuable information on cancer risks in organs and tissues such as the liver, skeleton, and nasal mucosa, as well as the lung.

The current planned order and schedule for completion of dosimetry and medical reviews during Fiscal Years 1994, 1995 and 1996 are given in Table 22. Because the ITRI team has responsibility for completion of some of the studies begun at the University of Utah in addition to the ITRI studies, these studies are also listed in Table 22 to reflect the total effort involved. Also, with the cooperation and collaboration of scientists from ANL, the results and materials from a life-span study of intravenously injected $^{137}CsCl$ in dogs originally conducted at ANL will be reviewed at ITRI in FY 1994. This review will follow completion of the ITRI study with $^{137}CsCl$, both studies being based on similar experimental designs.

Table 22

Projected Order and Schedule for Completion
of Dosimetry and Medical Reviews for
Life-Span Studies in Dogs at ITRI

FY 1994
^{224}Ra Citrate (Utah)[a]
$^{137}CsCl$ (ANL)[b]
^{144}Ce FAP
FY 1995
$^{239}PuO_2$ (3 sizes)
^{91}Y FAP
^{239}Pu Citrate (Utah, Immature)[a]
FY 1996
^{226}Ra Citrate (Utah, Immature)[a]
^{90}Y FAP
^{90}Sr FAP

[a]These studies, initiated at the University of Utah, will be completed at ITRI under the collaborative agreement.
[b]This study was conducted at ANL, but the reviews and core manuscript will be done at ITRI with collaboration from ANL staff.

Because of the maturity of the entire series of dog life-span studies at ITRI, most of the living dogs on study are also approaching the end of their life spans. Table 23 lists the number of dogs alive in each of the four studies containing living dogs and the projected year in which the last dog is expected to die. These studies will continue with the daily observation of the dogs, pathological examination of each animal when it dies, and the collection of excreta and tissues for radiochemical analysis for dosimetry. Each study will be integrated into the wrap-up schedule based on the projected date of death of all of the animals. In addition, samples of all tumors of sufficient size are being collected and preserved at -70°C for use in other projects. These samples provide valuable material for evaluating oncogenes and gene activation products present in radiation-induced tumors. Material is also available for *in situ* hybridization and immunohistochemistry studies.

Table 23

Predicted Dates for the Remaining Dogs to Die in the Life-Span Radionuclide Toxicity Studies

Radionuclide and Form	Completion of Inhalation Exposure (Years)	Number of Dogs Entered in Study	Number of Dogs Alive	Projected Year of Last Death
$^{239}PuO_2$ (0.75 μm)	1977-1979	60	1	1994
$^{239}PuO_2$ (1.5 μm)	1977-1979	108	4	1995
$^{239}PuO_2$ (Immature)	1979-1982	108	43	1998
$^{239}PuO_2$ (Repeated Exposures)	1977-1988	72	1	1994

2. Databases

Over the past 30 yr, a number of different database approaches have been used at ITRI for the purpose of managing the storage and retrieval of the data and records produced in different segments of the life-span studies program. These databases have involved a broad range of information on topics such as breeding, inoculation, clinical observations, clinical pathology results, necropsy reports, pathologic diagnoses, radionuclide counting data, and analytical radiochemistry results. Some of the previous databases used have been written in-house, and others were obtained from commercial sources. A long-standing problem has been the difficulty of retrieving and using data from several sources at the same time. Also, because of these database differences, the results were not in appropriate formats for eventual transfer to the NRA.

A concerted effort is continuing to re-establish these major databases within a common software framework. The FOCUS database software is being used for this purpose. Highest priority was given first to the development of a health effects database for use in the final review of all clinical and pathologic materials for each dog. Basic details of this database were given in the 1988-1989 annual report (LMF-128, pp. 84-85). This database is now an important tool in our health effects evaluation process. Other databases that have been set up in a FOCUS format include the colony management database, the clinical pathology database, the radionuclide counting database, and the analytical chemistry database.

E. RECENT RESEARCH ACCOMPLISHMENTS

1. Life-Span Health Effects of Relatively Soluble Forms of Internally Deposited Beta-Emitting Radionuclides

B. B. Boecker, B. A. Muggenburg, F. F. Hahn, K. J. Nikula, and W. C. Griffith

One important area addressed in the fission-product studies is the influence of *in vivo* solubility of the inhaled material on the doses received by, and the effects seen in, different organs and tissues. This report presents and compares results from three studies in which young-adult Beagle dogs inhaled $^{90}SrCl_2$ or $^{144}CeCl_3$, or were injected with $^{137}CsCl$. This comparison was chosen because of known differences in the pattern of metabolism and dosimetry among these three radionuclides, ranging from concentration mainly in one organ (^{90}Sr), several organs (^{144}Ce), and the whole body (^{137}Cs). Of particular interest are the relative distributions of radiation dose and long-term biological effects among organs exposed by these three regimens.

Young-adult Beagle dogs (12-14 mo, equal number of both sexes) inhaled, on a single occasion, different activity levels of either $^{90}SrCl_2$, or $^{144}CeCl_3$, or were injected once, intravenously, with $^{137}CsCl$. The exposure aerosols, consisting of the radionuclide plus a CsCl or $CeCl_3$ vector, had polydisperse size distributions with AMADs ranging from 1.5 to 2.4 μm (s_g = 1.6 to 2.1). Exposures were completed in less than 1 h. Each dog was whole-body counted immediately after radionuclide exposure and at selected intervals thereafter to determine the initial body burden and its retention as a function of time after exposure. Each dog's health status was evaluated periodically, and illnesses considered not to be associated with the radiation exposure were treated using standard veterinary practices. All dogs were maintained in the ITRI kennel facility until they died or were euthanized when moribund. Complete necropsies and histopathological examinations were performed. When all dogs in a study were dead, all clinical and histopathological results and materials were reviewed to ensure accuracy and consistency of the diagnoses. All diseases were coded for a FOCUS database using the SNODOG system. Absorbed beta doses were computed for individual organs or the whole body as appropriate for the radionuclides and forms used. These dose calculations were based on the whole-body retention data from each radionuclide-exposed dog in the longevity study and tissue distribution and retention data obtained from serially sacrificed dogs in separate, but similar, dosimetry studies. The small photon contribution was ignored, except for the whole-body dose from ^{137}Cs where the photon portion contributed about one-third of the total dose.

Table 24 presents the experimental design features for the three studies compared in this report. In each study, a range of long-term retained burdens was studied, the highest of which led to early deaths within the first 2 yr after exposure. Most of these early deaths were from hematologic dyscrasias resulting from irradiation of the bone marrow. Several others were due to radiation pneumonitis, pulmonary fibrosis, or hepatic degeneration. The focus of this report is on the remaining ~80% of the dogs that survived more than 2 yr after exposure and, therefore, were at risk for the development of cancer and other later-occurring diseases.

Table 24

Experimental Design Features for Life-Span Studies of
Dogs Exposed to Relatively Soluble Beta-Emitting Radionuclides

		Number of Dogs			
		Exposed		Controls	
Study	LTRB[a] (MBq/kg)	Total	>2 yr[b]	Total	>2 yr[b]
^{90}Sr	0.10 – 4.8	66	58	22	22
^{144}Ce	0.096 – 13	55	41	15	15
^{137}Cs	28 – 130	54	42	12	11

[a]LTRB = long-term retained burdens for exposed dogs.
[b]Survived more than 2 yr after exposure.

Cumulative absorbed dose factors (Gy per MBq/kg Long-Term Retained Burden) for organs in animals exposed to these three different patterns of radionuclide distribution are given in Table 25. The organs and tissues listed for ^{144}Ce are the four that received the highest total beta doses. Of these four, only two, bone and nasal mucosa, received significant doses from ^{90}Sr. In contrast, the relatively uniform whole-body distribution of ^{137}Cs produced about the same total dose (beta plus gamma) in all four organs.

Table 25

Cumulative Absorbed Beta Doses to 5000 Days after Exposure of Beagle Dogs to Radionuclides in a Relatively Soluble Form

	Gy per MBq/kg LTRB[a]		
Organ/Tissue	$^{90}SrCl_2$	$^{144}CeCl_3$	$^{137}CsCl$[b]
Lung	---[c]	24	0.15
Liver	---[c]	60	0.21
Bone	220	18	0.13
Nasal Mucosa	270	92	0.18
Whole Body	N/A[d]	N/A	0.21

[a]LTRB = long-term retained burden.
[b]Doses for ^{137}Cs include gamma contribution.
[c]--- = Dose <0.1% of skeletal dose.
[d]Not applicable.

Neoplasia was a prominent, long-term finding in both the exposed and control dogs (Gillett, N. A. *et al. JNCI 79*: 35, 1987; 1989-90 Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, p. 66, p. 70). Table 26 gives the number of dogs in which primary malignant or benign tumors were found. All tumors, whether they were the primary cause of death, a major contributing disease, or an incidental finding, are included. For this report, the controls for the three individual studies have been combined. One can roughly compare the number of tumors across the three exposed groups and the combined controls because the number of 2-yr survivors was about the same in each group.

The number of lung tumors was similar in all three exposed groups and the control group. These tumors were mainly bronchioloalveolar carcinomas and adenocarcinomas in dogs that died from 10 to 16.5 yr after exposure. The exceptions were two ^{144}Ce-exposed dogs that died at 4.5 and 7.6 yr after exposure in which a bronchioloalveolar adenoma and adenocarcinoma, respectively, were found. In the liver, bone, and nasal mucosa, pronounced differences were found between the exposed dogs and the controls. No tumors were found in these organs in the control dogs except for two bile duct adenomas in the liver. A large number of liver tumors, both malignant (hemangiosarcoma, hepatocellular carcinoma, cholangiocarcinoma, and neurofibrosarcoma) and benign (biliary cystadenoma and bile duct adenoma) were found in dogs exposed to ^{144}Ce or ^{137}Cs, but not to ^{90}Sr. In contrast, the tumorigenic response in the ^{90}Sr-exposed dogs was primarily the occurrence of bone tumors (osteosarcoma, hemangiosarcoma, and fibrosarcoma). No bone tumors were seen in the other groups, except one osteosarcoma that occurred in a ^{144}Ce-exposed dog at 2.2 yr after exposure. Tumors in the nasal mucosa, mostly carcinomas, occurred in all three studies, but not in the controls. The relative distribution of tumors between the $^{144}CeCl_3$ and $^{90}SrCl_2$ studies is consistent with the dosimetry information in Table 25. The occurrence of tumors in the livers and nasal mucosa of $^{137}CsCl$-exposed dogs indicates that these tissues are relatively responsive to this radiation insult.

Table 26

Occurrence of Primary Tumors in Selected Organs of Dogs that were Exposed to $^{90}SrCl_2$, $^{144}CeCl_3$, or $^{137}CsCl$ and Lived > 2 yr after Exposure or in Control Dogs

	Number of Tumors[a]			
Organ/Tissue	^{90}Sr	^{144}Ce	^{137}Cs	Controls
Lung	2,1[b]	3,1	3,0	5,0
Liver	0,1	10,11	5,5	0,2
Bone	45,1	1,0	0,0	0,0
Nasal Mucosa	3,0	5,0	4,0	0,0
Number of Dogs	58	41	42	48

[a]Some dogs had more than one tumor. In addition to the tumors listed, a number of tumors were found in other organs of dogs in each of these groups; many were incidental findings at necropsy.
[b]Number malignant, number benign.

These initial analyses have been directed to organs and tissues that have been clearly identified as targets of radiation from these and other internally deposited radionuclides. Investigations are continuing on the question of whether additional organs or tissues may also be at risk from these different patterns of chronic beta irradiation. These results are providing valuable *in vivo* information on the appropriateness of current radiation-protection practices for internally deposited radionuclides.

2. Bone Tumor Incidence in Beagle Dogs that Inhaled Soluble Radionuclides

B. A. Muggenburg, F. F. Hahn, B. B. Boecker, K. J. Nikula, R. A. Guilmette, and W. C. Griffith

One purpose of these studies involving soluble forms of fission-product radionuclides was to determine which organs would be at risk for the development of significant long-term biological effects. The skeletal system was considered to be one of the organs at higher risk for the development of cancers because several of these radionuclides were known to accumulate preferentially in bone.

The studies conducted with radionuclides that were relatively soluble in body fluids are listed in Table 27. Dogs in a particular study were exposed once, by inhalation, to one of these radionuclides except those exposed to $^{137}CsCl$, which was injected intravenously. In this list, ^{90}Sr has the greatest affinity for bone and deposits throughout the volume of the bone resulting in a large percentage of the dogs developing bone tumors (Table 28). After inhalation, ^{144}Ce and ^{91}Y translocate from the lung primarily to liver and skeleton. The physical half-life of ^{144}Ce is a little over 9 mo, while that of ^{91}Y is about 2 mo. Although nearly half of the activity translocated from lung deposited in bone, only one bone tumor was observed in the ^{144}Ce study, and none was observed in the ^{91}Y study. The $^{137}CsCl$ injected intravenously resulted in an accumulation in soft tissues and a general whole-body irradiation. Although tumors were observed in some organ systems, no bone tumors were observed. The alpha-emitting radionuclide ^{238}Pu (inhaled as $^{238}PuO_2$), which has a radioactive half-life of approximately 88 yr, was also a part of this series. Approximately equal fractions of the ^{238}Pu that entered the blood from the lung were deposited in the liver and skeleton. The ^{238}Pu was deposited primarily on bone surfaces and resulted in a large percentage of the dogs developing bone tumors.

Table 27

Studies of the Toxicity of Various Radionuclides Inhaled or Injected in Relatively Soluble Chemical Forms and Their Distribution Characteristics in the Skeleton

Radionuclide	Type of Radiation	Radioactive Half-life	Primary Tissue Distribution
^{90}Sr	beta	29 yr	Bone volume
^{144}Ce	beta, gamma	285 days	Bone surfaces and liver
^{91}Y	beta, gamma	59 days	Bone surfaces and liver
^{137}Cs	beta, gamma	30 yr	Muscle and soft tissues
^{238}Pu	alpha	88 yr	Bone surfaces and liver

Each study had a group of control dogs (Table 28). None of the control dogs associated with these studies developed bone tumors. However, three bone tumors have been observed in a group of over 250 control dogs from all longevity studies at the Institute.

Bone tumors in the exposed dogs were primarily osteosarcomas or soft tissue sarcomas primary to bone (fibrosarcoma, hemangiosarcoma, myxosarcoma). In the ^{90}Sr study, 36% of the bone tumors were hemangiosarcomas or fibrosarcomas. With $^{238}PuO_2$, less than 2% of the bone tumors were soft tissue sarcomas. The tumors within the skeleton from the ^{90}Sr were mainly distributed in the skull and long bones of the limbs.

Some other tumors observed in the dogs may be related to the accumulation of radioactivity in the skeleton. Tumors of the bone marrow (leukemias and myeloproliferative disorders) were noted in several dogs exposed to $^{90}SrCl_2$ or $^{144}CeCl_3$. Both of these radionuclides are beta emitters with prolonged retention in bone. No such tumors were seen in studies with $^{91}YCl_3$, $^{137}CsCl$, or $^{238}PuO_2$. Tumors of the nasal and sinus mucosa were also found in 5 to 10% of the dogs in each study with beta-emitting radionuclides. None was found in

the dogs that inhaled $^{238}PuO_2$. Tumors of the oral mucosa were also found in dogs exposed to $^{90}SrCl_2$, $^{144}CeCl_3$, $^{137}CsCl$, or $^{238}PuO_2$. One hypothesis for the occurrence of these oral and nasal tumors is that radiation from the radionuclide in the bone surrounding the mouth, nasal cavity, and sinuses induced the tumors of the epithelial lining cells. In the case of ^{137}Cs, the soft tissue distribution of the radionuclide suggests this may not be the mechanism for that particular radionuclide. However, the tissue distribution of ^{137}Cs around the nose and mouth has not been studied closely. The inability of the alpha radiation from the ^{238}Pu in the bones surrounding the nasal cavity and sinuses to reach the epithelial lining cell might explain why only one tumor was observed in these tissues in the dogs that inhaled ^{238}Pu. No tumors of the nasal cavity have been observed in the control dogs associated with these studies or in a larger group of controls from other longevity studies.

Table 28

Number of Bone and Bone-Associated Tumors Found in Dogs that Inhaled or Were Injected with Radionuclides

Radionuclide	Number of Dogs	Number of Dogs Surviving > 2 yr	Dogs with Bone Tumors	Dogs with Bone-Marrow Tumors	Dogs with Nasal-Mucosal Tumors	Dogs with Oral Mucosal Tumors
$^{90}SrCl_2$	66	54	30	2	3	1
$^{144}CeCl_3$	55	41	1	3	5	3
$^{91}YCl_3$	42	29	0	0	3	0
$^{137}CsCl$	54	41	0	0	4	3
$^{238}PuO_2$	144	142	90	0	0	1
Controls	85	85	0	0	0	0

Comparison of the number of bone tumors observed in dogs that inhaled or were injected with various beta-emitting or an alpha-emitting radionuclides suggests that the tumors occurred primarily in studies with the longer-lived radionuclides. Significant differences exist in the distribution of tumors within the skeleton and the occurrence of possible bone-associated tumors between the beta- and alpha-emitting radionuclides.

As these studies are completed through final reviews and analyses of the dosimetry, clinical, and histopathological data and publication of core manuscripts, the bone cancer risks across these studies and those in other DOE laboratories will be analyzed. Of particular interest will be the comparisons of bone cancer risk factors for chronic beta and alpha irradiation and the examination of studies in which few or no bone cancers were observed even though the skeleton was irradiated.

3. Primary Lung Cancer in the Longevity Study/Control Population of the ITRI Beagle Dog Colony

F. F. Hahn, B. A. Muggenburg, and W. C. Griffith

The incidence and types of primary lung neoplasms found in unexposed dogs are critical in determining the long-term biological effects of inhaled radionuclides. The frequency of lung neoplasms in dogs is generally considered to be low, but incidence rate is difficult to document in pet populations. In North America and Europe, reports of lung carcinoma occurrence range from 0.1% (Nielsen, S. E. In *The Lung* [A. A. Liebow and D. E. Smith, eds.], Williams and Wilkins, Baltimore, p. 226, 1968) to 1% (Stunzi, H. *Pathol. Microbiol. 39*: 358, 1973) for dogs that die and are necropsied. In a survey of all types of neoplasms in the pet dog population of two counties in Northern California, the incidence rate for lung cancer, as diagnosed in dogs admitted to veterinary clinics, was 4.2 per 10,000 dogs per year (Dorn, C. R. *et al. J. Natl. Cancer Inst. 40*: 295, 1968). Here, we report the incidence of primary lung neoplasms in a group of 225 Beagle dogs observed for their normal life span.

The dog colony at ITRI, composed of purebred Beagle dogs, was initiated in 1962. The breeding colony has been closed to the entry of new dogs since 1965. In 1968, a generation breeding program was initiated to establish and maintain a stable gene pool (Bielfeldt, S. W. *et al. Am. J. Vet. Res. 30*: 2221, 1969). The initial generation consisted of 40 female and 20 male dogs.

The longevity study control population consists of all control dogs included in life-span studies of inhaled radionuclides conducted at ITRI and allowed to live out their normal life spans. These control dogs are listed in the appendix tables of this report. One control group is not included: the life-span studies of aged dogs, since the animals were selected for study at 8-10.5 yr of age.

The characteristics of the control population are noted in Table 29. The selection criteria and frequency of clinical examinations were the same as for the exposed dogs and similar among longevity studies, although the studies were initiated over a period of 12 yr.

Table 29

Characteristics of Longevity Control Dog Population

Number of Dogs	Age at Selection	Selection Criteria	Frequency of Clinical Examination
225 total 116 females 109 males	13 ± 1 mo (except 18 were 12 ± 1 wk)	Normal size[a] Normal facial configuration Normal hematologies Normal blood chemistry Normal radiographs Normal EEG & EKG	Once per year on birthday As needed for illness Yearly radiographs

[a]Dogs too large to fit into standard whole-body counting box and abnormally small dogs were not used.

All dogs were given a complete necropsy at death or euthanasia that included all organ systems. All major organs, as well as lesions, were routinely sampled for histopathologic examination.

The survival and age distribution of the population at risk and the age-specific incidence of tumors were determined using a life-table method of analysis (Rosenblatt, L. S. *et al. Health Phys. 21*: 869, 1971). The cumulative incidence of tumors is the sum of the age-specific incidence times the probability of survival to that age (Elandt-Johnson, R. C. and N. L. Johnson. *Survival Models and Data Analysis*, John Wiley and Sons, NY, 1980). The BMDP1L Life Tables and Survival Functions statistical software package was used for data analysis.

As of September 30, 1992, 204 dogs (109 males and 95 females) had died or been euthanized. The cumulative survival is shown in Figure 30. The median survival time of the males is greater than the females (14.1 yr vs. 13.7 yr); however, the survival curves are not significantly different as demonstrated by the generalized Savage, Tarone-Ware, and generalized Wilcoxon statistical tests.

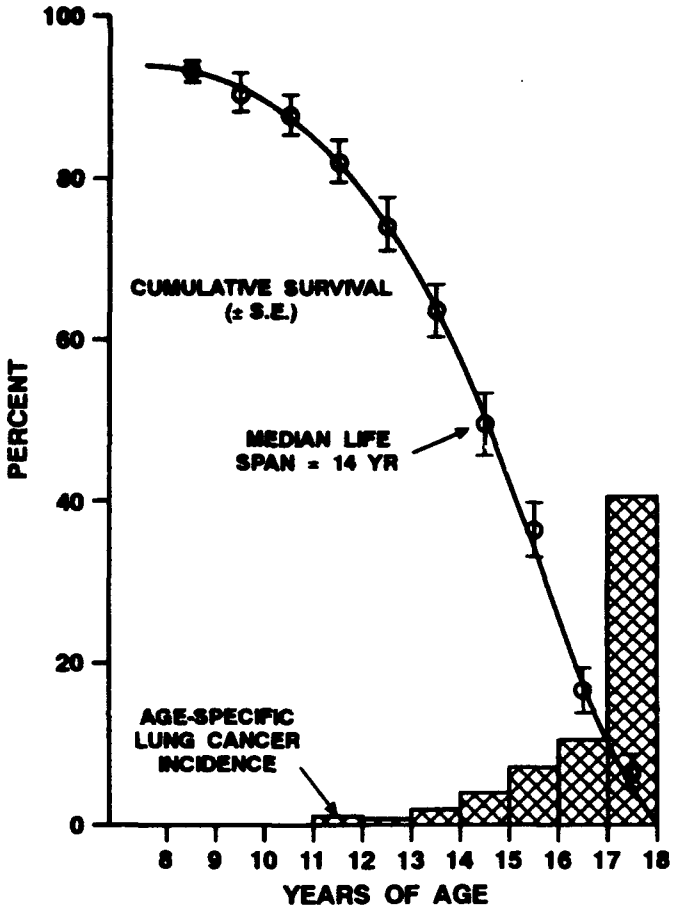


Figure 30. Longevity of control dogs and incidence of primary lung neoplasms (status as of 9/30/92).

The crude incidence of lung neoplasms was greater in females (10%) than in the males (6.4%) based on the number of dogs that had lung tumors and the number dead as of September 30, 1992. However, statistical comparison of these cumulative incidence curves shows no significant difference in the tumor incidence in males and females. This lack of predilection is consistent with previous reports of lung tumor incidence in pet populations (Moulton, J. E *Vet. Pathol. 18*: 513, 1981).

The age-specific incidence of tumors is also shown in Figure 30. The incidence markedly increases after 14 yr of age and is nearly 10% after 16 yr in both males and females. The age-dependence of lung neoplasms has been noted anecdotally but has been quantified in only one previous publication. A report of the lung tumor incidence in the Beagle dog colony at the University of Utah shows an increased incidence with increased age; however, the absolute incidence is considerably lower than that reported here (Taylor, G. N. *et al. Am. J. Vet. Res. 40*: 1316, 1979). For example, the age-specific incidence at 13 to 16 yr is reported to be 0.7% compared to 4.2% for the similar interval in the ITRI longevity control colony.

This study indicates that the primary lung tumor incidence is higher in Beagle dogs than in other species used in long-term studies, with the exception of some mouse strains. For example, in three species frequently used in the Institute, F344 rats have a lifetime incidence of about 1%, $C_{57}Bl/J$ mice approximately 2%, and Syrian hamsters essentially 0%.

Seventeen primary lung neoplasms were found in the control dogs (Table 30). The earliest occurring lung tumor resulted in the dog's death at 11.1 yr of age. The latest occurring was found in a 17.6-yr-old dog that died of renal failure.

Table 30

Summary of Primary Lung Neoplasms Detected in Control Dogs for the Longevity Studies

Dog Number	Age at Death (yr)	Type of Death[a]	Primary Cause of Death or Euthanasia	Lung tumor Type	Metastasis
Males					
859C	12.7	E	Lung tumor	Papillary adenocarcinoma	No
401A	14.0	D	Lung tumor	Papillary adenocarcinoma	No
1122C	14.2	E	Lung tumor	Papillary adenocarcinoma	No
378A	14.4	E	Lung tumor	Bronchioloalveolar carcinoma	Yes
361B	14.6	D	Lung tumor	Bronchioloalveolar carcinoma	Yes
56A	15.1	E	Olfactory neuroblastoma	Papillary adenocarcinoma	No
998A	15.1	E	Lung tumor	Papillary adenocarcinoma	Yes
Females					
10C	11.1	D	Lung tumor	Papillary adenocarcinoma	No
405W	11.2	D	Anesthetic death	Papillary adenocarcinoma	No
348S	13.6	E	Renal failure	Papillary adenocarcinoma	No
689U	14.1	E	Lung tumor	Papillary adenocarcinoma	No
1152T	15.0	E	Lung tumor	Adenosquamous carcinoma	Yes
407T	15.7	E	Renal failure	Papillary adenocarcinoma	No
61C	15.8	D	Lung tumor	Papillary adenocarcinoma	Yes
663S	16.1	D	Lung tumor	Adenosquamous carcinoma	No
762T	17.6	D	Nephritis	Papillary adenocarcinoma	No
283C	17.6	D	Septicemia	Bronchioloalveolar carcinoma	Yes

[a]E = Euthanized; D = Died

All of the lung tumors were carcinomas. Most (12/17) were papillary adenocarcinomas, but three were bronchioloalveolar carcinomas, and two were adenosquamous carcinomas. The morphologic appearance of these tumor types overlaps in some cases. However, the difference in morphologic pattern may have biologic significance. For example, epidermal growth factor receptor expression in canine lung tumors, as determined by immunohistochemistry, is phenotype-dependent, being predominantly seen in papillary adenocarcinomas and squamous cell carcinomas and not in bronchioloalveolar carcinomas (Gillett, N. A. *et al. Vet. Pathol. 29*: 46, 1992).

Metastasis, usually to thoracic lymph nodes and tissues only, occurred in six cases (35%). Two of three bronchioloalveolar carcinomas had metastases, and 4 of 12 papillary adenocarcinomas had metastases. The lung tumor was the primary cause of death in 11 of the 17 tumor cases.

The lung tumor types reported here are similar to those in pet populations reported by others. One group reported 74% adenocarcinomas and 20% alveolar carcinomas (bronchioloalveolar carcinomas) in 210 cases (Ogilvie, G. K. *et al. J. Am. Vet. Med. Assoc. 195*: 106, 1989). Another group reported 77% adenocarcinomas and 15% alveolar carcinomas (bronchioloalveolar carcinomas) in 171 cases from pet populations (Moulton *et al.*, 1981). A review of 11 primary lung neoplasms in the University of Utah Beagle dog colony noted 10 adenocarcinomas (Taylor *et al.*, 1979.)

In summary, this study shows that Beagle dogs do not have a low incidence of primary lung neoplasms, but the incidence is dominated by a high age-specific incidence late in life.

4. Growth Rate Patterns of Lung Tumors in Beagle Dogs Exposed to $^{239}PuO_2$ or $^{238}PuO_2$

W. C. Griffith, J. H. Diel, B. A. Muggenburg, and S. J. Matthews

Inhalation exposure studies have been conducted in Beagle dogs to investigate the risk of lung tumor induction by α-radiation from relatively insoluble inhaled particles of $^{238}PuO_2$ or $^{239}PuO_2$. This report investigates the growth rate patterns for lung tumors induced in these studies. These tumor growth rate patterns are of interest because they aid in evaluation of the dose-response relationships for inhaled Pu.

Knowledge of the tumor growth rate assists in analyzing dose-response relationships by providing a more appropriate estimate of the dose and the tumor incidence rate. At the time of death, the size of a lung tumor varies greatly, suggesting that lung tumors are present for differing lengths of time before death. The tumors may be detected before death during routine surveillance of the dogs, but their sizes at time of detection are again highly variable. A tumor's growth rate and its size at death can be used to estimate a time when it was a certain size, so that all dogs can be standardized to the same tumor size. A small uniform size is used so that the estimated time is closer to when the tumor is likely to have arisen. The calculation of the tumor incidence rate is simplified by use of a time point early in the development of the tumor when the tumor is not likely to have affected survival. Because of the long retention half-lives of ^{239}Pu and ^{238}Pu in the lung, the radiation dose is delivered over long time periods, with part of the dose delivered after a tumor is present. Estimation of a standardized time endpoint for a tumor will eliminate variability in the dose due to the time between when a tumor reaches a uniform size and death.

The objectives of this project were to (1) develop a method to measure pulmonary tumor dimensions from radiographs; (2) select an appropriate method of calculating volume from two-dimensional images on a radiograph; and (3) determine and analyze tumor growth rate and doubling time.

To estimate lung-tumor growth, radiographs of 174 dogs that developed pulmonary neoplasms were examined. Dogs from three studies were included: single and repeated inhalation exposures to $^{239}PuO_2$ and a single inhalation exposure to $^{238}PuO_2$. The criteria for selection in each data set were (1) a single tumor with discrete boundaries exhibited in both dorsoventral and lateral views and (2) three or more serial radiographs showing the tumor that were taken over at least a 1-mo period.

Some of the 174 radiographs examined exhibited clearly delineated tumors in one view only. Other radiographs were clouded by the diffuse nature of the tumor's edges in the lung, especially those involving bronchioloalveolar carcinomas. Twenty-nine cases met our criteria. Information pertaining to tumor classification, exposure history, and metastasis was collected for each dog selected. Radiographic films in which the tumors were clearly visible ranged over a period of 57 to 578 days. With the aid of a light box, both radiographic views, dorsoventral and lateral, of the tumor perimeters were traced on paper. The cross-sectional tumor perimeters resembled circles or ellipses. The number of tracings of each dog differed with the number of radiographs taken between the time that the tumor was first observed to when the dog died, and ranged from 3 to 14. The tracings were digitized using a Graf/Pen data collection software program that was developed at ITRI. The program approximated the area of each tumor by applying the trapezoidal rule.

In recent studies in dogs (Rooser, B. *et al. ACTA Oncology 26(3)*: 189, 1987; Perry, R. R. *et al. Am. J. Vet. Res. 53(10)*: 1740, 1992), tumor volumes have been computed by assuming the tumor configuration to be spherical or ellipsoidal. In this project, it was assumed that tumor growth was uniform in all directions. Geometrically similar figures (i.e., the ratio of the dimensions are the same) would then be projected in each set of dorsoventral and lateral radiographs. Similarity of figures implies that the ratio of the volumes is proportional to the ratio of the areas raised to the three-halves power. This relationship was the basis for computing tumor volume. Tumor volume was plotted against days prior to death after the first noted occurrence of the tumor in the radiographs (Fig. 31).

Linear curves were estimated by least-squares regression for transformed data points for both dorsoventral and lateral views. The data were transformed by the natural logarithm of tumor volume as the dependent variable which was regressed on days prior to death as the independent variable. In most cases the slopes of the lines formed for both views appeared to be approximately the same. Single component exponential growth rates and doubling times were computed. Many of the curves appeared to be exponential. However, the growth

rates of individual tumors differed among dogs. The data suggest that growth rates of Pu-induced lung tumors have doubling times ranging from 1 to 9 mo.

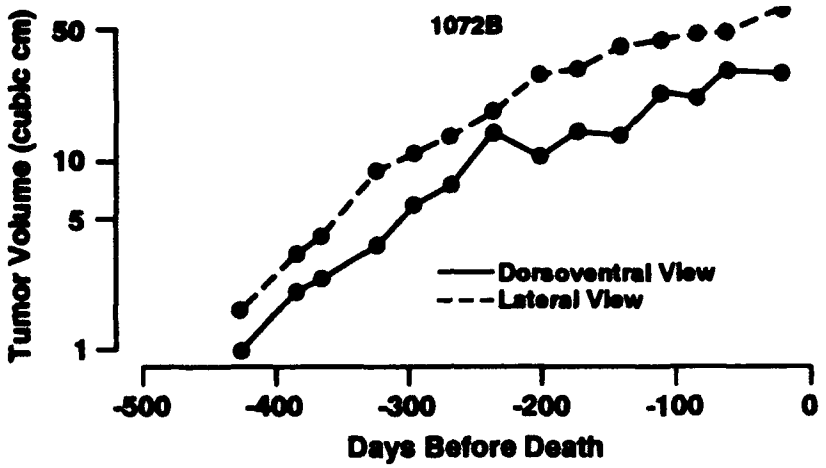


Figure 31. Example of tumor growth showing tumor volumes estimated from radiographs of dorsoventral and lateral views of the tumor at various times before death for dog 1072B.

Further statistical analysis indicated that tumors which had maximum final volumes between 20 cm^3 and 125 cm^3 fell into two distinct groups of doubling times. One group had doubling times between 1 and 3 mo. Those for the other group ranged from 6 to 9 mo. There were no tumors with maximum volumes between 20 cm^3 and 125 cm^3 that had doubling times between 3 and 6 mo (Fig. 32).

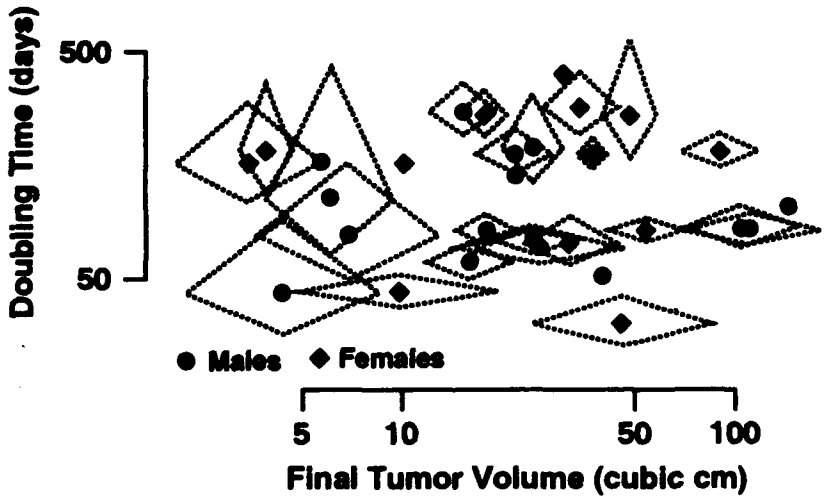


Figure 32. Tumor doubling times as a function of final tumor volume at death. The quadrilaterals illustrate the magnitude of the 95% confidence intervals determined from the linear regression for the doubling time and final tumor volume. The smaller quadrilaterals indicate that the doubling times and final volume are known more precisely. For points without quadrilaterals, the 95% confidence intervals were so broad in at least one direction that they did not fit onto the graph.

Tumor type, exposure history, and metastasis were factors that were considered for each dog. For the 29 cases reviewed, six of the tumors were classified as papillary adenocarcinoma, two as adenocarcinoma, one as adenosquamous carcinoma, one as squamous carcinoma, one as bronchioloalveolar carcinoma, and 18 as

carcinoma. Metastasis occurred in 17 cases. No relationship among doubling times and gender, histologic type, age at death, lung burden, or metastasis was established.

The results of this study suggest that tumor growth rates can be used for estimation of the time at which lung tumors are a uniform size. The standard errors for the growth rates can be reduced by observation of the tumors over a longer period of time. The similar growth rates for both dorsoventral and lateral view data suggest that the sample size could be increased by focusing on the lateral-view radiographs. Frequently, observation of the dorsoventral view was obscured by the position of the tumor in relation to the heart. Relaxing the selection criteria to use these views would provide observations over longer periods of time.

The results of this study suggest estimation of the time when the lung tumors had a volume of about 1 cm^3 would be appropriate. This size of lung tumor is about as small as can be detected on a radiograph. This size of tumor is close to or inside the range of the data. Thus, it would only involve a small extrapolation. Also, the growth rate down to this size appears to be approximately exponential, so that the time estimated by this procedure is likely to have small bias.The growth before a lung tumor reaches a volume of 1 cm^3 probably involves a period of much more rapid growth than those observed for the majority of tumors in this study. The slow growth rates in Figure 32 observed for many of the tumors would extrapolate back to times of origin, as a single cell, before the dog was exposed. This suggests these tumors have a period of more rapid growth, which is consistent with the observation in these studies that very few dogs have incidental lung tumors found at death when the dog dies of causes other than a lung tumor.

5. Prediction of Survival Times after Repeated Exposures Based on Survival Times Following a Single Exposure of Beagle Dogs by Inhalation to $^{239}PuO_2$

J. H. Diel

Knowledge of the effects of inhalation exposure to radionuclides is highly variable depending on the type of radiation, the species, the time sequence of exposure, and many other factors. Consequently, we must find a means of using our knowledge in the areas that are reasonably well known to predict what might happen in other situations. This paper describes an approach to predict the survival time after repeated inhalation exposures based on a single exposure to the same material. The method is used in the context of exposures of relatively long-lived animals where only a few animals are exposed and makes maximal use of the information from each individual animal to obtain the best prediction.

The study that was used to evaluate this method of prediction is one in which Beagle dogs were exposed by inhalation to aerosols of $^{239}PuO_2$, either once or repeatedly at 6-mo intervals until clinical signs of radiation pneumonitis or pulmonary fibrosis appeared (Diel, J. H. *et al. Radiat. Res. 129*: 53, 1992). Survival time was measured as the time from first or only exposure until the dogs died a natural death or were euthanized for humane reasons.

The assumption used for the determination of the relative effectiveness of single and repeated exposures was that the same effect is produced independent of the time sequence of radiation dose accumulation if the same cumulative radiation dose is achieved at the same time after exposure. This assumes that the energy deposited and the time required for the biological system to respond to that energy deposition are both important. This is equivalent to equal effects being produced for animals having the same average dose rate at death.

Retention of Pu in the lung of a dog exposed once by inhalation to $^{239}PuO_2$ was characterized by a two-component, negative exponential function. Retention of Pu from repeated exposures was obtained by adding the retention of Pu from each exposure. Half-times of retention were assumed to be the same for repeated exposures as for single exposures, but the fraction retained depended on the number of previous exposures. Dose rate was obtained by calculating the energy deposited per unit mass of the lung. Dose is the integral over time of the dose rate, and average dose rate is the total dose to a given time divided by the time.

The average dose rate versus effect equation used assumes that the time to death from radiation pneumonitis and pulmonary fibrosis was proportional to some power of the average dose rate. The variability of the individual values about this predicted relationship was assumed to be log-normal and of equal variance for all values of the average dose rate on a log scale.

For this model, the average dose rate and survival time of each dog exposed once and dying of radiation pneumonitis and pulmonary fibrosis were used as individual points in fitting the data to the average dose rate versus effect equation. The resulting measure of variability was used to predict the probability of a repeatedly exposed dog with a given average dose rate dying of radiation pneumonitis and pulmonary fibrosis at a given time.

Because some of the repeatedly exposed dogs died from causes other than radiation pneumonitis and pulmonary fibrosis, comparison of the predicted survival with the measured survival required that the measured survival time data be corrected for competing causes. Standard methods (Kaplan, E. L. and P. Meier. *J. Am. Stat. Soc. 53:* 457, 1958) were used for this correction.

Retention of Pu in the lungs of dogs exposed once was characterized by a two-component exponential equation with 28% retained with a half-time of 63 days and the remaining 72% retained with a half-time of 1333 days. For the repeated exposures, the fraction retained at the shorter half-time depended on the number of previous exposures; it varied from 28% for the first exposure to 3% for the tenth exposure.

Dogs dying of radiation pneumonitis after a single inhalation exposure survived from 891 to 2741 days after exposure and died with average dose rates ranging from 1.0 to 9.2 Gy/day. The average dose rate (*ADR*--Gy/day) versus survival time (*T*--days) was found to be:

$$T = 219\ ADR^{-0.474}\ .$$

The variability around this fit was relatively small with a geometric standard deviation of 1.052. To check the consistency of the results with the assumptions of the model, the values of the differences between the logs of the predictions and the logs of the measured survival times for the dogs dying of radiation pneumonitis were computed. For each average dose rate, the values were found to be consistent with the assumption that the variability was the same for all values of the independent variable and had a normal distribution with mean 0 (Wilk-Shapiro test, $p > 0.1$).

Figure 33 compares the survival prediction of the model with the Kaplan-Meier corrected survival data. The differences between the data and predictions were not statistically significant (Kolmogorov-Smirnov test, $p > 0.2$).

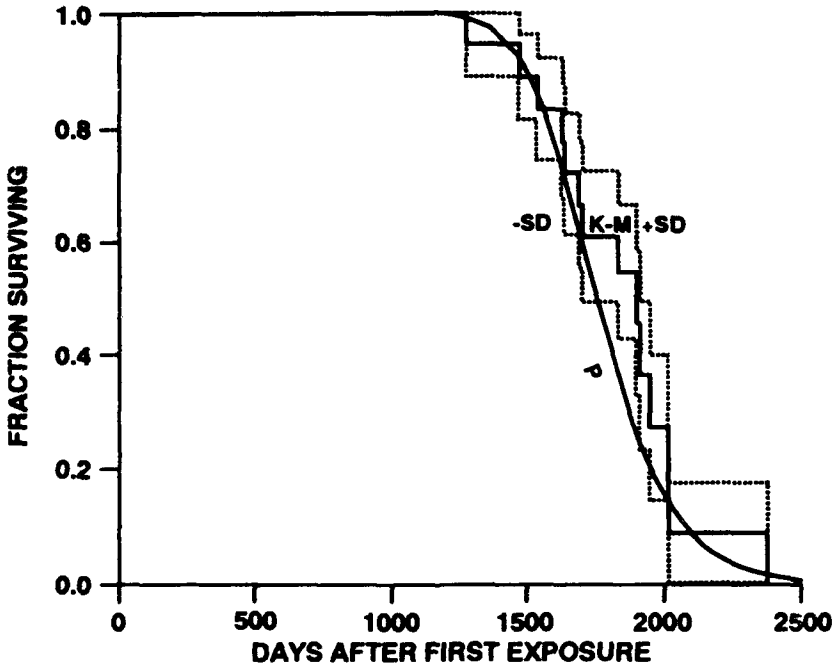


Figure 33. Survival predictions for dogs exposed repeatedly and dying of radiation pneumonitis (P) based on measured survival after a single exposure compared to Kaplan-Meier (K-M) estimates of survival of repeatedly exposed dogs dying with the effect. Standard deviation of survival (± SD) is also based on Kaplan-Meier.

The method presented is useful for predicting average response to a different time sequence of exposure. Average dose rate takes into account both total energy deposited and the time over which this energy is deposited. The average dose rate is appropriate for this prediction as would be expected for this early occurring effect that results from accumulated damage to the lung.

II. UNIVERSITY OF UTAH LIFE-SPAN STUDIES IN DOGS

A. SPECIFIC PROJECT OBJECTIVES

In 1950, the U.S. Atomic Energy Commission initiated a series of long-term radionuclide toxicity studies in Beagles at the University of Utah. At that time, the use of ^{239}Pu for weapons and as a potential source of nuclear fuel was increasing, and plutonium production was a rapidly expanding industry. Because of the known toxicity of radium in humans, the potential toxicity of plutonium was recognized. The original studies at the University of Utah were designed to determine the relative toxicity of ^{239}Pu and ^{226}Ra. Because some human radium toxicity data were available, the animal studies were originally designed to reflect the human experience with ^{226}Ra, providing a basis for extrapolating the long-term toxicity of other internally deposited radionuclides, particularly plutonium from animal studies to humans. As detailed below, the life-span effects of other nuclides were also included in this project.

The Beagle dog was selected for these studies because of concerns that erroneous predictions of human health effects might be made if shorter-lived mammals, such as rodents, were used. These concerns included the possibilities that the radiation-sensitive cancers would only be expressed in animals with longer life spans and that the target organs might be different in rodents than in humans. Because skeletal tissues were recognized as a primary target organ for radium and plutonium toxicity, further consideration was given to the Beagle because it has skeletal characteristics similar to those of humans that rodents do not have.

The major scientific questions that have been, and continue to be, addressed in the life-span radionuclide studies conducted at the University of Utah include:

(1) What are the biological distribution and retention patterns of these nuclides?

(2) What types of cancers are produced?

(3) What are the dose-effect relationships?

(4) Can differences in retention and distribution be used to predict biological response?

(5) Does age at exposure influence biological response?

(6) What biological factors are important in biological tissues for the expression of radiation effects?

(7) What are the target cells for cancer induction?

(8) What are the cellular and molecular mechanisms of cancer induction by internally deposited radionuclides in different organs?

(9) Can reliable models be developed for predicting risk to humans?

B. EXPERIMENTAL APPROACHES

1. General Procedures

Two general types of studies have been conducted in dogs: life-span studies and sacrifice studies. In life-span studies, the toxicity of selected radionuclides is being studied, and the dogs are allowed to live out their life spans, unless sacrifice is indicated for humane reasons. In sacrifice or test studies, dogs were injected with radionuclides to study the mechanisms of deposition, retention, and specific radionuclide-tissue interactions.

Most of the dogs in the toxicity studies received a single intravenous injection of radionuclide, usually in citrate solution, at 16 to 18-mo old, when their skeletal maturity corresponded to that of an 18-yr old radium dial painter or plutonium worker. In addition, some dogs were injected with ^{239}Pu or ^{226}Ra at 3 mo of age (to represent children) or 5 yr of age (to represent middle-aged persons). The dogs were confined in metabolism cages 1 wk before injection and 3 wk after injection (for excreta collection). Exceptions were the dogs receiving one or a series of 10 or 50 injections of ^{224}Ra starting at 21-mo old. These dogs were not confined after

injection because the period of injections extended to about 1 yr. In addition, confinement could have interfered with important biological functions.

Each dog in a toxicity study has been followed clinically from the time of injection to death. At death, each dog receives a complete gross necropsy examination, including radiographs of defleshed bones to identify possible tumor sites that are then examined histologically. Histopathological examinations are performed on both the radiation-induced and naturally occurring lesions. These results are then analyzed with regard to the average and local radiation doses received by the affected tissues. Various dose-response relationships are tested for their appropriateness and usefulness in predicting the human health risks for such an exposure.

Because of the maturity of a number of these studies, current emphasis at the University of Utah is directed to activities necessary to complete the studies and publish the results. The radiochemical, metabolic, and dosimetric data for both completed and continuing toxicity studies are being collected, collated, and archived. The distribution and local dosimetry of the radionuclides are being studied by using materials collected from both the toxicity and test animals. Average retention, dose, and dose-rate functions for liver and skeleton are being calculated and studied as functions of age at exposure, exposure level, and time after exposure. The occurrence,type, location, and latent period of radiation-induced cancers will be studied both as functions of local or average dose and of dose rate. Dose-response curves are being constructed to extrapolate the health effects seen in these dogs to human health risks.

A critical aspect of this research is the preparation of a complete biological record for each dog and assembly of the observations into a clinical and pathology data base that can be used with the detailed dosimetric data to establish meaningful dose-response relationships for the various radionuclides that have been studied in this program.

The final products of these efforts are publications in the peer-reviewed literature dealing with the observed dose-response relationships and health risk estimates and with a wide range of underlying metabolic, dosimetric, and mechanistic studies. The above efforts are divided between scientists at the University of Utah and ITRI.

2. Study-Specific Features

This research effort addresses the completion of 14 major life-span studies of dogs given single or multiple intravenous injections of different alpha or beta-emitting radionuclides. The studies included and the time intervals during which dogs were entered on study are described below:

a. ^{239}Pu (Injected from 1952-1974)

Initially, the injected dosages ranged from 0.59 kBq/kg (0.016 μCi/kg) (termed "1-level") from which no harm was predicted, up by a sequence of levels to 106 kBq/kg (2.86 μCi/kg) (termed "5-level") from which severe injury occurred, including hematological damage, liver degeneration and neoplasia, and bone fractures and sarcomas. However, in 1964, when an osteosarcoma occurred at the supposedly safe, 1-level, several lower levels were introduced. The lowest level, 0.022 kBq/kg (0.0006 μCi/kg) (the 0.1-level), resulted in an average skeletal dose of about 0.02 Gy (? rads) at death. Among the 28 dogs treated at the 0.1 level, one developed a bone sarcoma and another an epidermoid carcinoma of the frontal sinus; both cancers may have been induced by the ^{239}Pu. The selective deposition of ^{239}Pu on bone surfaces makes this radionuclide the most effective of any studied at the Radiobiology Division for inducing bone sarcoma at low doses, per rad of average of skeletal dose. ^{239}Pu also deposits throughout the liver and induces liver cancers.

b. ^{226}Ra (Injected from 1953-1970)

^{226}Ra enabled the relative toxicity of ^{239}Pu vs. ^{226}Ra to be established in Beagle dogs, so that the known toxicity in the U.S. radium dial painters could be used to predict the risk to humans from ^{239}Pu-induced bone sarcoma. ^{226}Ra is chemically similar to calcium and deposits throughout the bone volume, especially in regions of active growth. The average skeletal dose for each dog was based on the measured retention of ^{226}Ra and progeny. In Beagle dogs, ^{226}Ra at higher dosages produced bone fractures. Bone sarcomas were induced over a wide range of doses. These effects were also seen in the radium dial painters.

c. ^{228}Ra (Injected from 1954-1962)

^{228}Ra was included in these studies because it was received by many of the radium dial painters. In terms of average skeletal dose, ^{228}Ra was about twice as effective as ^{226}Ra for inducing bone sarcoma. The difference may be largely due to the fact that some ^{228}Ra progeny are likely to redeposit on bone surfaces. An important spinoff from the study of ^{228}Ra in dogs was the discovery that the physical half-life of ^{228}Ra is 5.77 ± 0.02 yr, not 6.7 yr, as was earlier reported by Lise Meitner. Correcting for the proper half-period increased the calculated dose from ^{228}Ra in the dial painters by about a factor of two over earlier estimates.

d. ^{228}Th (Injected from 1954-1963)

^{228}Ra decays to ^{228}Th, and there was early concern that the intestinal absorption of the ^{228}Th in dial painters might be high. Later, it was found that absorption of ^{228}Th from the human GI tract was low, about 0.02% compared to 20% for radium. However, the ^{228}Th toxicity data from Beagle dogs proved very useful for evaluating the risk from radionuclides in the proposed Thorium Breeder Reactor.

e. ^{90}Sr (Injected from 1955-1966)

^{90}Sr toxicity was evaluated because of worldwide concern about radioactive fallout from atmospheric nuclear weapons testing. Few effects were observed at average skeletal doses below 50 Gy (5000 rads), but bone sarcomas occurred frequently at higher doses. Most interesting was the relative ineffectiveness of ^{90}Sr in producing leukemia in adult Beagle dogs. This observation agrees with the low frequency of myeloproliferative syndrome (MPS) observed in Beagle dogs at the University of California, Davis, that were injected once with ^{90}Sr as adults. However, a high incidence of MPS was observed in the Davis Beagle dogs exposed to a high dosage of ^{90}Sr administered by feeding from fetal age to adulthood.

f. ^{241}Am (Injected from 1966-1975)

^{241}Am was the first transplutonium radionuclide to be evaluated for toxicity in Beagle dogs at the University of Utah. Because of strong interest in ^{241}Am, especially by Charles Dunham, Head of the AEC's Division of Biology and Medicine, the original test study was expanded into a full-scale toxicity study, with about 12 dogs per dosage level. Control dogs concurrently assigned to the low-level studies of ^{239}Pu and ^{226}Ra were considered suitable as controls for the ^{241}Am studies. In 1975, the number of Beagle dogs at the 1- and 1.7-levels was increased to 26 and 24 dogs, respectively, to study the induction of liver cancer by alpha-emitters more extensively. The liver retains more ^{241}Am than any other monomeric radionuclide studied in Beagle dogs at the University of Utah.

g. ^{249}Cf (Injected from 1971-1974)

^{249}Cf, which emits alpha-particles in 100% of its decays, was the next transplutonium radionuclide to be investigated. Fortuitously, tracer amounts of beta-emitting ^{249}Bk were present with the alpha-emitting ^{249}Cf, making it possible to establish that the microscopic depositions of Bk and Cf were similar.

h. ^{252}Cf (Injected from 1971-1973)

^{252}Cf releases half of its decay energy in alpha-particles and half in extremely densely ionizing fission fragments. The ^{252}Cf and ^{249}Cf studies were run simultaneously in Beagle dogs and in mice. In the mouse studies, the fission fragments of these radionuclides were much less effective than alpha particles per Gy of average skeletal dose for inducing bone sarcoma. It is already obvious that the fission fragment dose is much less effective than the alpha-particle dose for inducing bone sarcoma in Beagle dogs. This information is significant to the astronaut who may receive appreciable radiation dose to bone from extremely densely ionizing cosmic rays.

i. ^{253}Es (Injected from 1973-1974)

Einsteinium (element 99) was the highest element on the periodic chart to be investigated for radionuclide toxicity in Beagle dogs. Einsteinium appeared to resemble Cf most closely in its excretion, retention and tissue distribution. No bone sarcomas occurred among the five toxicity-study Beagle dogs injected with ^{253}Es, excluding the one dog that subsequently received a large dose of ^{249}Cf. This suggests that ^{253}Es, which delivers its dose with a 20-day half-life, is not appreciably more toxic than the other transplutonium elements studied.

j. ^{224}Ra (Injected from 1977-1979)

Toxicity studies with ^{224}Ra ($T\frac{1}{2}$ = 3.62 days) were undertaken to understand the modifying effect of protraction on the dose-response of ^{224}Ra observed in German ankylosing spondylitis patients. Four graded-dose levels were administered over three injection spans. Groups 1-2 received their ^{224}Ra in 50 weekly fractions to correspond to the average injection span in German children; Groups 41-52 received a single injection, and Groups 81-92 received 10 weekly injections to correspond to the more recent treatment used in Germany for ankylosing spondylitis. Most of the ^{224}Ra given the Beagle dogs was prepared by Amersham-Buchler in Germany, which also prepared the ^{224}Ra for the German ankylosing spondylitis patients. The studies of ^{224}Ra in Beagle dogs are among the most important with respect to understanding the mechanisms of alpha-particle-induced cancer. The short half-life of ^{224}Ra causes some of it to decay on bone surfaces and some to decay within the bone volume, giving a local distribution of dose in bone somewhat similar to that from ^{239}Pu. In the Beagle dogs receiving 2.8 Gy (280 rad) from ^{224}Ra injections protracted over 50 wk, the bone sarcoma appearance times and incidences were similar to those observed from the same skeletal dose from ^{239}Pu. It remains to be seen, however, what the effectiveness of ^{224}Ra will be at lower doses and shorter protraction times. The ^{224}Ra study, being the most recent, has the largest number of living dogs.

k. Toxicity Studies in Immature and Aged Beagle Dogs

Because of concern about the effects of radionuclides on members of the general public with widely different ages, the studies in Beagle dogs were expanded to include administration at 3 mo of age (to represent children) and 5 yr of age (to represent middle-aged adults). ^{239}Pu was selected as the bone-surface-seeking radionuclide of greatest concern, while ^{226}Ra was chosen to represent the bone-volume seeking radionuclides. Much attention has been given to the effect of changing distribution of radioactivity with age in these dogs and to the associated biological effects.

C. CURRENT STATUS OF THE UTAH STUDIES

General Overview

The current status of the 14 life-span radionuclide toxicity studies initiated at the University of Utah is given in Table 31. On September 15, 1987, all living dogs in these studies, 157, were moved to the ITRI colony for continuation of their care and biomedical evaluation for the remainder of their lives. Between September 15, 1987 and September 30, 1991, 118 of these transferred dogs died. During the past two fiscal years, an additional 33 dogs died, resulting in a population of 6 living dogs on September 30, 1993. These deaths reflect the maturity of these studies and the dogs in them at the time of transfer. These living dogs are part of the populations in two studies, the ^{224}Ra study in young adult dogs and the study of ^{226}Ra in immature dogs.

The research currently devoted to the Utah efforts fall into three main areas: (1) continuation of the care and study of dogs still alive in these six studies, (2) detailed dosimetric studies, at the organ and local levels, of these injected radionuclides and the factors that influence these dose patterns, and (3) completion of final reviews of biological materials and data, compilations and analysis of data, and preparation of final study reports for publication in the open, scientific literature.

Table 31

Current Status of Life-Span Radionuclide Toxicology Studies in Beagle Dogs Initiated at the University of Utah and Being Continued at the Inhalation Toxicology Research Institute (9/30/93)

Age at Injection	Radionuclide Injected	Injection Year	Dogs Entered in Study	Dogs Transferred 9/15/87	Number Alive		
					9/30/91	9/30/92	9/30/93
16-18 mo (young adult)	^{239}Pu	1952-1974	286	11	0	0	0
	^{226}Ra	1953-1970	164	0	0	0	0
	^{228}Ra	1954-1962	89	0	0	0	0
	^{228}Th	1954-1963	94	0	0	0	0
	^{90}Sr	1955-1966	96	0	0	0	0
	^{241}Am	1966-1975	117	8	0	0	0
	^{249}Cf	1971-1974	36	5	0	0	0
	^{252}Cf	1971-1973	36	3	0	0	0
	^{253}Es	1973-1974	6	0	0	0	0
	^{224}Ra	1977-1979	128	78	22	9	5
3 mo. (immature)	^{239}Pu	1972-1978	75	24	9	3	0
	^{226}Ra	1975-1978	54	24	8	5	1
5 yr. (aged)	^{239}Pu	1975-1978	34	3	0	0	0
	^{226}Ra	1975-1980	34	1	0	0	0
		Total	1249	157	39	17	6

D. COMPLETION ACTIVITIES FOR THE UTAH STUDIES

Because of the joint ITRI/Utah involvement in the completion of Utah studies, lead roles have been assigned for the various studies as shown in Table 32. In the studies in which most or all of the dogs have already died, Utah has the lead role, whereas ITRI will assume the lead role for those studies that will be completed later. Present wrapup emphasis is directed toward the studies in which young adult dogs were injected with ^{226}Ra or ^{239}Pu. The strategy for the analysis of each study includes a thorough review of all records including pathology, clinical, radiographic, dosimetric, radiochemical, and metabolic. For each study, a series of milestones has been established and specific oversight assignments given to specific investigators. The primary goal is to produce a document that summarizes all data in the study. In addition, numerous smaller, more specific papers are being published as the work progresses.

An example of the working "Milestone Schedule" for the Radium Young-Adult study is shown in Table 33 and its detailed footnotes. A similar schedule has been developed for the ^{239}Pu study as shown in Table 34. The appended footnotes explain some of the analyses being done for this wrap-up effort. The same types of approaches will be used to the maximum extent possible within the framework of future resources available for this work. Table 35 lists a number of projected manuscript subjects that should flow from the ITRI/Utah collaborations.

Table 32

Currently Planned Division of Efforts to Complete and Publish the Lifetime Toxicity Studies in Beagle Dogs from the University of Utah

Radionuclide	Age Category	Lead Institution
^{226}Ra	Young Adult	U. of Utah
^{90}Sr	Young Adult	U. of Utah
^{239}Pu	Young Adult	U. of Utah
^{228}Ra	Young Adult	U. of Utah
^{228}Th	Young Adult	U. of Utah
^{241}Am	Young Adult	U. of Utah/ITRI
^{249}Cf	Young Adult	U. of Utah/ITRI
^{252}Cf	Young Adult	U. of Utah/ITRI
^{253}Es	Young Adult	U. of Utah/ITRI
^{226}Ra	Aged	U. of Utah/ITRI
^{239}Pu	Aged	U. of Utah/ITRI
^{226}Ra	Immature	ITRI
^{239}Pu	Immature	ITRI
^{224}Ra	Young Adult	ITRI

Table 33

Milestone Schedule for Completion of
Summary Report on ^{226}Ra Young Adult Dog Longevity Study
(September 30, 1993)

Topic	Status
Historical review	Complete
Experimental designs	Complete
Histopathology, SNOMED [a]	Complete
Expanded controls [b], SNOMED	Complete
Metabolism, retention	
General [c]	Complete
Model developed from new data from individual bones and plasma[d]	Pending
Gross dosimetry [e]	Complete
Survival analyses [f]	
Low doses	Complete
High doses	Pending
Dose-response (bone tumor incidence) [g]	Complete
Hematopoietic, lymphoid response	
Summary of old data [h]	Complete
Final tumor data [i]	Complete
Other soft tissues [j]	Complete
Skeletal tissues	
Skeletal tumor, verification [i]	Complete
Skeletal tumor, location [i]	Complete
Radiography [k]	Pending
Histology, microradiography [l]	Pending
Fractures [m]	Complete
Tooth loss [n]	Complete
Local dosimetry [o]	Pending
Jaw syndrome [n]	Complete
Discussion and summary [p]	Pending
Review and submission [q]	Pending

[a] SNOMED: Systemized Nomenclature of Medicine, College of American Pathologists. This is the standardized database for all histopathology. This database is on a Digital microVAX system and is transferred to the National Radiobiology Archive.

[b] Expanded controls: In addition to the control dogs assigned to this study (R0.0), controls from other studies have been included in many of the analyses to increase the validity of comparing radiation and nonradiation effects. These controls are included in all models and statistical comparisons.

[c] General metabolism: The metabolism of radium (and some other nuclides) is determined from the "test" animals and not the "chronic toxicity" animals. There were serial sacrifice studies done for early distribution, localization, and dosimetric studies.

[d] **Plasma:** Results from a shorter term metabolism study are pending. These data will allow more precise determinations of blood nuclide levels and improvements in present metabolic models.

[e] Gross dosimetry: Average skeletal dose calculated for each dog.

[f] Survival analyses: Presently, Cox proportional hazard models are being applied for survival analyses to the different dose groups. The statistical models are complicated by a number of factors including the need to censor animals with epilepsy, and use of control and treated animals over 3 decades with improved life expectancy due to improved veterinary practices. Initial analyses with low dose groups have been published. Analyses are continuing in higher dose groups.

[g] Tumor incidence: Emphasis is on skeletal tumors. Only those tumors that were verified histologically are included in these analyses. In some cases, the histological diagnosis may be disputed. The location of the tumors is documented from clinical, necropsy and radiographic records. The location of the tumors and the apparent type of tissue or origin (*e.g.*, cancellous or cortical bone) become very important parts of the skeletal dosimetry studies.

[h] Old hematology data: Due to the bone-seeking nature of these isotopes, it was originally believed that hemic tumors would be an important consequence of radionuclide exposure. This was not observed in the human or early animal studies, and a programmatic decision was made by the A.E.C. to end the detailed hematopoietic studies in the early 1970s. We have, and continue, to review the early records and reports to reconstruct the data, although very limited. Little hematological information is available for the studies after the mid-1970s.

[i] Final hematological tumor data: The final incidence of hemic and lymphoid tumors is verified.

[j] Other soft tissues: Although not historically emphasized in these studies, the histopathology and clinical records have been reviewed and the data tabulated. Recently over 400 soft tissue tumors have been evaluated and the data statistically assessed and submitted for publication.

[k] Radiography: Radiographic summaries are prepared on each dog and entered into the clinical record on the database. Attempts are also being made to quantify some dose-response relationships in the radiographs. This effort is complicated by the fact that there are substantial changes in the skeletal tissues that may be attributable to aging seen in many, but not all dogs. Presently a descriptive summary is being prepared.

[l] Histology and microradiography: A summary of the histology (independent of skeletal tumors) and microradiographic changes is being prepared.

[m] Fractures: Increased fracture occurrence is a known consequence of Ra exposure. The incidence and location of fractures has been updated and summarized.

[n] Tooth loss and periodontal tissue changes are also known to occur with Ra exposure. The loss of teeth and the rate of tooth loss have been determined and are correlated with increasing dosages. The changes in oral tissues (jaw syndrome) are documented and summarized.

[o] Local, cellular dosimetry: This productive effort involves collaboration with Dr. Erich Polig, Karlsruhe, Germany. Dr. Polig spent about 4.5 yr in our laboratory and developed and applied an automated scanning microphotometer system for the radium dosimetry studies. From these data and companion biology studies, extensive cellular dose models have been constructed and published.

[p] Summary: The summary will be considered complete when the items identified above are finished, with the exception of the local dosimetry program which will continue.

[q] Publications are submitted to peer-reviewed journals. In addition to the "Summary Paper(s)", a number of articles dealing with specific scientific issues will continue to be published in appropriate journals.

Table 34

Milestone Schedule for Completion of
Summary Report on ^{239}Pu Young Adult Dog Longevity Study
(September 30, 1993)

Topic	Status
Historical review	Pending
Experimental designs	Complete
Histopathology, SNOMED	
Clinical summaries	Complete
Radiographic summaries	Complete
Metabolism	
General	Complete
Short term studies	Pending
Gross dosimetry	Complete
Soft tissues - dosimetry	Complete
Liver, kidney, spleen	Complete
Other soft tissues	
Dose-response	
Tumor incidence	
Skeletal	Complete
Soft tissue	Pending
Survival analyses	
Low doses	Complete
Higher doses	Pending
Hematology	Pending
Skeletal tissues	
Skeletal tumor, verification	Complete
Skeletal tumor, location	Complete
Radiography	Pending
Histology	Pending
Microradiography	Pending
Autoradiography	Pending
Fractures	Complete
Jaw	Complete
Local dosimetry	Pending
Soft tissues	
Liver	Complete
Gonad	Complete
Other	Complete

Table 35

Projected Future Manuscript Subjects from the ITRI/Utah Collaborations

Radium

- Ra bone hit - local dosimetry
- Ra dose-response - all doses with survival models
- Ra mammary tumors (manuscript submitted)
- Ra soft tissue tumors (manuscript submitted)
- Ra eye tumors (manuscript in press)
- Ra daughters and leukemia (published, 1993)
- Ra summary (pending dose-response and local dosimetry analyses)

Plutonium

- Pu bone tumors, dose-response (published, 1993)
- Pu toxicity ratios for bone tumors (manuscript submitted)
- Pu bone metastases (manuscript submitted)
- Pu bone tumor occurrence - specific sites (manuscript submitted)
- Pu dose-response - all doses with survival models
- Pu local dosimetry and metabolism
- Pu dosimetry all tissues
- Pu summary

Americium

- Am dose-response
- Am specific tumor sites
- Am/Pu and other nuclide bone cancer induction (manuscript submitted)
- Am and thyroid lesions (published, 1993)
- Am local dosimetry and metabolism
- Am summary

Cross-cutting manuscripts

- Comparison of effectiveness for bone cancer induction, ^{239}Pu, ^{226}Ra, ^{224}Ra, ^{228}Th, ^{228}Ra, ^{249}Cf, ^{90}Sr, ^{253}Es (manuscript submitted)
- Tumor growth and metastases for all nuclides (manuscript in press)
- Summary of liver tumors and other soft tissues

With ITRI

- Ra/Pu retention and distributions as functions of growth and skeletal maturity, juvenile, young adult and aged animals

E. RECENT RESEARCH ACCOMPLISHMENTS

1. Distribution of Skeletal Malignancies in Beagles Injected with ^{239}Pu Citrate

R. D. Lloyd, G. N. Taylor, W. Angus, S. C. Miller, F. W. Bruenger, and W. S. S. Jee

The distribution of 84 skeletal malignancies in 76 Beagle dogs injected with ^{239}Pu as young adults (Lloyd, R. D. *et al. Health Phys. 64*: 45, 1993) roughly seems to follow the distribution of skeletal mass and skeletal ^{239}Pu (Table 36). These findings are similar to those we reported earlier for a group of dogs given ^{226}Ra (Lloyd *et al.*, 1993) . Although there were differences in tumor distribution between the animals given ^{226}Ra and those given ^{239}Pu (Table 37), most of them were not statistically significant. However, the radium dogs seemed to show a greater sensitivity to bone tumor origin in the tibia, while there may have been a tendency among the plutonium dogs toward increased relative sensitivity in the scapula, lumbar vertebrae, sacrum, and ribs. In contrast, the most common site for the formation of naturally occurring bone malignancy in the dog is the distal radius (Brody, R. S. *et al. J. Am. Vet. Med. Assoc. 143*: 471, 1963). Perhaps there were too few tumors and too few dogs in our study to establish statistical significance.

A correlation between tumor location and at least two anatomical-physiological factors in the skeleton indicated that these two factors (site-specific bone turnover rate and percent of red marrow at the site, which is correlated with vascularity) may influence the appearance of malignancies both individually and in combination. Table 38 indicates that the sensitivity for a given skeletal location (e.g., proximal humerus or distal femur) of bone malignancies among Beagle dogs given ^{239}Pu might be correlated with the percent of red marrow at the site of tumor origin, which also indicates the degree of vascularization. The coefficient of determination, or square of the correlation coefficient, "r," (Woolf, C. M. In *Principles of Biometry*, D. Van Nostrand Co. Inc., Princeton, NJ, 1968), obtained for linear regression in a comparison of percent red marrow with percent tumors was, $r^2 = 0.56$. A similar conclusion was also made independently for the occurrence of plutonium-induced tumors in preliminary reports from this laboratory (Miller, S. C. *et al.* In *Life-span Radiation Effects Studies in Animals: What Can They Tell Us?* [R. C. Thompson and J. A. Mahaffey, eds.], Office of Scientific and Technical Information, Springfield, VA, p. 286, 1986; Smith, J. M. *et al. Radiat. Res. 99*: 324, 1984) which were prepared a few years before the final histopathology reports were completed.

Bone turnover rates at the specific bone locations (samples were derived mainly from cancellous or trabecular bone) appear to have a slightly less pronounced correlation with bone tumor appearance, with $r^2 = 0.54$. The multiplicative combination of these two parameters (column 6 in Table 38) appears to be a somewhat better predictor of sensitivity to tumor formation than either one alone (with $r^2 = 0.69$ for the parameters merged) and was done to indicate the combined effects of both parameters. Miller *et al.* (1986) investigated parameters other than marrow type and bone turnover rate, such as trabecular bone mass, bone cell population, bone cell activity, density of osteogenic precursor cells, plutonium uptake on bone surfaces, and bone-marrow microvasculature. All of these except trabecular bone mass, marrow type and bone turnover rate were important contributors to their effects on bone tumor occurrence. A strong linear relationship was not found between trabecular mass and tumor incidence in only the few sites reported by Miller *et al.*, but these also cited a more comprehensive study (Gong, J. K. *et al. Anat. Rec. 149*: 325, 1964) of the same factors that did not seem to support this relationship. The work of Gong *et al.* (1964) indicated that even though there was a positive relationship between the number of bone tumors and trabecular mass, the relationship may not be linear.

Except for the femur ($p = 0.038$), there appeared to be no difference ($p > 0.10$) between the relative distribution of skeletal malignancies of low-level (30 Bq to 2 kBq kg^{-1} injected) and high-level (3 to 122 kBq kg^{-1}) dogs. Distribution of bone tumors between the axial and appendicular skeleton was 50% vs. 50% for ^{239}Pu (42 and 42), but it was 39% axial vs. 61% appendicular (22 and 35, respectively) for dogs given ^{226}Ra. However, this difference was not significant ($p > 0.2$).

Table 36

Comparison of the Malignant Bone Tumor Distribution in the Skeletons of Beagle Dogs Given ^{239}Pu with the Distribution of Skeletal Mass or ^{239}Pu Activity (± S.D.)

Bone	Number of Tumors	Percent Tumors[a]	Percent Skeletal Mass[b]	% Tum[c] / % Mass	"p"[d]	Percent Skeletal Activity[e]	% Tum[f] / % Act	"p"[d]
Radii	1	1.19(1.18)	2.4(0.19)	0.50(0.50)		1.08(0.35)	1.10(1.15)	
Ulnae	2	2.38(1.66)	2.5(0.13)	0.95(0.66)		1.01(0.32)	2.36(1.80)	
Humeri	11	13.1(3.68)	6.6(0.33)	1.98(0.56)	>0.05	9.87(1.83)	1.33(0.45)	
Scapulae	5	5.95(2.58)	3.9(0.47)	1.53(0.69)		5.20(0.68)	1.14(0.52)	
Paws	1	1.19(1.18)	9.6(0.65)	0.12(0.12)	<0.05	3.76(1.13)	0.32(0.33)	>0.05
Tib+Fib[g]	2	2.38(1.66)	5.8(0.36)	0.41(0.29)	>0.05	3.52(0.75)	0.68(0.50)	
Femurs	10	11.9(3.53)	6.8(0.48)	1.75(0.53)	>0.05	7.88(1.40)	1.51(0.52)	
Pelvis	10	11.9(3.53)	5.1(0.42)	2.33(0.72)	>0.05	7.21(0.85)	1.65(0.53)	>0.05
(Appendicular Skeleton)	42	50.0(5.46)	42.7(3.1)	1.17(0.15)		39.5(8.73)	1.27(0.31)	
Skull	6	7.14(2.81)	15.6(1.6)	0.46(0.19)	>0.05	8.44(2.09)	0.85(0.40)	
Mandibles	3	3.57(2.02)	6.1(0.71)	0.59(0.34)	>0.05	2.76(0.95)	1.29(0.85)	
Ribs	5	5.95(2.58)	9.6(0.79)	0.62(0.27)	>0.05	11.6(1.56)	0.51(0.23)	>0.05
Sternum	0	0.00(1.19)	2.7(0.72)	0.00	<0.05	2.93(0.96)	0.00	>0.05
Cerv V	5	5.95(2.58)	6.5(0.72)	0.92(0.41)		5.45(1.07)	1.09(0.52)	
Thor V	9	10.7(3.37)	7.1(0.79)	1.51(0.50)		14.7(2.25)	0.73(0.26)	
L V+Sac	14	16.7(4.07)	8.2(0.75)	2.04(0.53)	>0.05	13.9(1.56)	1.20(0.32)	
Tail	0	0.00(1.19)	1.3(0.36)	0.00	>0.05	0.68(0.23)	0.00	
(Axial Skeleton)	42	50.0(5.46)	57.1(8.2)	0.88(0.16)		60.5(14.0)	0.83(0.21)	
Total	84		99.8[h]			100.0[h]		

[a] Percent tumors in each bone of the total of 84. Uncertainties shown are the standard deviations (SDs) for the binomial distribution (Sokal, R. R. and Rohlf, F. J. In *Biometry*, W. H. Freeman and Co., San Francisco, CA, 1969).

[b] Data were taken from Lloyd *et al.* (*Health Phys. 60*: 435, 1991); the uncertainties are the SDs of the measurements for the 64 dogs included in the earlier study.

[c] Column 3 divided by column 4; the SDs shown were derived from the SDs of the values in columns 3 and 4 and are undefined in the case of zero tumors.

[d] The "p" values in columns 6 and 9 were taken to be: "p" < 0.05 = the ratio of % tumors and either % skeletal mass or % skeletal ^{239}Pu activity were different from 1.0 by more than ± 1.96 SDs; "p" > 0.05 = ratios different from 1.0 by < ± 1.96 SD but by > ± SD; and (blanks) "p" > 0.10 = the ratios were different from 1.0 by less than ± 1 SD.

[e] Data taken from page 143 of Lloyd *et al.* (In *Radiobiology of Plutonium*, [B. J. Stover and W. S. S. Jee, eds.], J. W. Press, Salt Lake City, UT, p. 141, 1972); the uncertainties are the SDs of the measurements for the 20 dogs included in the earlier study.

[f] Column 3 divided by column 7; the SDs shown were derived from the SDs of the values in columns 3 and 7 and are undefined in the case of zero tumors.

[g] Tibiae plus fibulae and including patellae.

[h] Os penis not included (for males only).

Table 37

Malignant Bone Tumor Distribution in the Skeleton of Beagle Dogs Given Either ^{239}Pu or ^{226}Ra-Citrate by Intravenous Injection. Comparisons were Done by Odds- Ratio Chi-Square Analysis with Yates' Correction for Continuity (Sokal and Rohlf, 1969).

Bone	57 ^{226}Ra Dog Tumors	84 ^{239}Pu Dog Tumors	Odds Ratio (Relative Risk)	95% Confidence Interval	"p"
Radii	2	1	3.018	0.27-23.82	0.566
Ulnae	2	2	1.491	0.18-8.12	1.000
Humeri	5	11	0.638	0.21-1.83	0.600
Scapulae	0	5	(a)		0.071
Paws	3	1	4.611	0.52-32.42	0.303
Tib+Fib+Pat.	10	2	8.723	2.05-32.96	0.004
Femurs	9	10	1.387	0.55-3.50	0.681
Pelvis	4	10	0.558	0.16-1.76	0.506
(Appendicular Skeleton)	35	42	1.591	0.85-3.00	0.245
Skull	7	6	1.820	0.60-5.56	0.460
Mandibles	4	3	2.038	0.45-7.55	0.440
Ribs+Stern	0	5	(a)		0.071
Cervical Vert	4	5	1.192	0.31-4.50	1.000
Thoracic V	4	9	0.629	0.18-2.02	0.654
L V+Sac+Tail	3	14	0.278	0.07-0.93	0.076
(Axial Skeleton)	22	42	0.629	0.33-1.18	0.245
Total Skeleton	57	84			
Dogs with Tumors	43	76			
Dogs at Risk	120	234			

[a] No odds ratio or 95% confidence interval can be calculated for a comparison in which one member of the pair has zero tumors. The probability shown is that for Fisher's Exact 2 tailed "p" value (Sokal and Rohlf 1969, pp 589).

Table 38

Comparison of Tumor Distribution in Beagle Dogs Given ^{239}Pu (this study) with the Occurrence of Red Marrow Sites in Bones of the Skeleton and with Bone Turnover Rates for Cancellous or for Trabecular Bone (both taken from p. 288 of Miller *et al.*, 1986). [Not included in this table are five skeletal malignancies for which Miller *et al.* (1986) did not provide data on percent red marrow or turnover rate at the specific skeletal location.]

Bone, Location	Number of Tumors	Percent Tumors	Estimated Percent Red Marrow	Bone Location[a] Turnover Rate, Percent y^{-1}	(Col 4 x Col 5 x 0.001)[b]
Prox Radius	1	1.3	0	127	0.0
Dist Radius	0	0.0	0	85	0.0
Prox Ulna	0	0.0	0	56	0.0
Dist Ulna	0	0.0	0	45	0.0
Prox Humerus	9	11.4	75	143	10.7
Dist Humerus	1	1.3	25	57	1.4
Scapula	5	6.3	100	97	9.7
Paws	1	1.3	0	67	0.0
Prox Tibia	2	2.5	25	112	2.8
Dist Tibia	0	0.0	25	66	1.6
Prox Femur	8	10.1	75	138	10.4
Dist Femur	2	2.5	75	122	9.2
Ischium (pelvis)	4	5.1	75	143	10.7
Ilium (pelvis)	4	5.1	75	164	12.3
Skull	6	7.6	50	65	3.2
Mandible	3	3.8	25	109	2.7
Ribs	5	6.3	75	121	9.1
Sternum	0	0.0	75	97	7.3
Cerv Vertebrae	5	6.3	100	122	12.2
Thor Vertebrae	9	11.4	100	167	16.7
Lumb Vertebrae	11	13.9	100	205	20.5
Sacrum+Tail	3	3.8	50	132	6.6
Total This Comparison	79	100.0			

[a] Applies to a specific bone location (distal radius, proximal radius, etc.) and mainly includes data derived for cancellous or for trabecular bone at the particular site.

[b] Columns 4 and 5 were multiplied to yield an arbitrary parameter that would represent the effects of both estimates, percent red marrow and bone turnover rate; multiplication by 0.001 was simply to make the magnitude of the parameter more manageable.

About one-third of all skeletal malignancies among the dogs in this study given ^{239}Pu occurred in the vertebral column, whereas less than one-fifth of the ^{226}Ra-induced tumors originated in the vertebrae (Table 37). Even though the significance of this difference could not be established from our data ($p > 0.05$), it should not have been surprising that the first (and so far only) reported bone tumor observed among humans contaminated above background levels with ^{239}Pu (Voelz, G. L. and Lawrence, J. N. P. *Health Phys. 61*: 181, 1991) was in vertebral bone (sacrum, Los Alamos National Laboratory Subject 20; United States Transuranium Registry Case 262). Jee W. S. S. *et al.* (*Strahlentherapie 80* [Suppl]:75, 1986) reported that no bone sarcomas had by then (1984) been reported in the cervical, thoracic, or lumbar vertebrae of persons contaminated with ^{226}Ra in spite of the fact that these structures contain a high proportion of trabecular bone. This observation has been extended in a more recent report (Schlenker, R. A. *et al.* In *Risks from Radium and Thorotrast*, BIR Report 21, [D. M. Taylor *et al.*, eds.], British Institute of Radiology, London, p. 55, 1989) to show that only two persons in the radium series had a skeletal malignancy in the sacrum and just one person had a malignancy involving several vertebrae.

2. Occurrence of Metastases in Beagle Dogs with Skeletal Malignancies Induced by Internal Irradiation

R. D. Lloyd, W. Angus, G. N. Taylor, G. B. Thurman*, and S. C. Miller

Metastases from malignant bone tumors often are responsible for the fatal effects of these cancers. Various characteristics of primary skeletal malignancies in a group of Beagle dogs injected with bone-seeking radionuclides were reported in detail by Thurman, G. B. (University of Utah Report COO 119-243, 1971) and summarized by Thurman, G. B. *et al.* (*Growth 35*: 119, 1971). Recent completion of the histopathology reports for nearly all life-span dogs studied during the period 1952 to 1987 at the Radiobiology Laboratory, University of Utah, made it possible for us to compare the occurrence of grossly apparent metastases from skeletal malignancies induced by skeletal irradiation from internal emitters (^{226}Ra, ^{239}Pu, ^{228}Ra, ^{228}Th, ^{90}Sr) with a number of other factors unique to each animal.

There were 212 malignant bone tumors in 186 of these dogs for which we subsequently received information on their metastatic occurrence. These data have enabled us to correlate the parameters reported previously with the appearance of bone tumor metastases. Data available for the animals included growth-rate of the primary tumor, volume of the primary tumor at death, sex of the animal, growth period of the primary tumor ("age"), degree of calcification of the primary tumor, skeletal location of the primary tumor (identity of the bone, side of the body, location along the length of a long bone), cumulative radiation dose to the skeleton at the estimated beginning of primary tumor growth, dose equivalent to the skeleton at the same point in time, and year of death.

Growth period (length of time between tumor initiation and the death of the dog) and tumor volume at death were arranged separately in order of increasing values, and each list was marked off into quartiles (fourths). Growth periods ranged from 193 to 1990 days; the minimum tumor volume at death was 0.3 cm^3, and the maximum was 1167 cm^3. Division into quartiles also was used for analysis of cumulative radiation dose to the skeleton vs. frequency of metastasis and for a corresponding analysis of dose equivalent (dose multiplied by a quality factor that allows for the differing relative sensitivity of the Beagle dog to the induction of bone sarcoma by various radionuclides at the same average skeletal dose). The quality factors in Beagle dogs, expressed as the effectiveness relative to ^{226}Ra, for the various radionuclides were taken from published reports: Lloyd, R. D. *et al.* (*Strahlentherapie 80*: 65, 1986) for ^{226}Ra = 1.0, ^{228}Ra = 2.0, and ^{228}Th = 8.5; NCRP Report No. 110 (1991) for ^{90}Sr = 0.1; and Lloyd, R. D. *et al.* (*Health Phys. 64*: 45, 1993) for ^{239}Pu = 16.

For any data set marked into quartiles and for which a significant difference in proportion of metastases was found by the "*t*" test between subgroups, the non-parametric Kendall rank correlation test (Siegel, S. *Non-parametric Statistics*, McGraw-Hill, New York, 1956) was used to determine the significance of any trend that could be identified within the entire data set. Data sets divided into quartiles were analyzed (Sokal, R. R. and F. J. Rohlf. In *Biometry*, W. H. Freeman, San Francisco, p. 70, 1969) by Odds-Ratio Chi Square methods with Yates' correction for continuity, supplemented by Fishers Exact Test for comparisons having zeros in any category. Proportions of tumors that metastasized from the various bones of the skeleton were compared by means of their relative uncertainties.

Each value of number of tumors yielding metastases and total number of tumors in the same bone were assigned an uncertainty based upon the standard deviation for the binomial distribution (Sokal and Rohlf, 1969). For a pair of data with values within 1 S. D., the "p" value was taken to be > 0.10; for those outside 1.0 but within 1.96 S. D., the "p" value was taken to be > 0.05; and for those outside of 1.96 S. D., the "p" value was taken to be < 0.05, all compared with respect to the corresponding data for the entire skeleton. The growth rates (mean doubling times) for various categories of primary skeletal malignancies (with or without metastases) were compared by means of the Group Comparison ("*t*") Test.

Some of the animals had more than one skeletal malignancy. If these were of different cell types, the identity of the tumor that was the origin of the metastases found in other tissues was not in doubt. Because most of the primary tumors were classified as osteosarcomas, including multiples in the same animal, we could not be sure which primary tumor was the origin of the metastases in dogs with more than one primary bone

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tumor. Therefore, we analyzed the data such that we counted the growth rate of (1) only the most rapidly growing tumor in each dog with multiple tumors, (2) only the most slowly growing tumor in animals with multiple tumors, (3) only the most rapidly growing tumor in the dogs with metastases and only the most slowly growing tumor in the dogs without metastases, or (4) only the most rapidly growing tumor in the dogs without metastases and only the most slowly growing tumor in the dogs with metastases. In addition, only those dogs with just a single primary tumor were included in another analysis to ensure that the correct malignancy could be identified as the source of a given metastasis. If there was a substantial difference in the probability of metastatic development between tumors with different growth rates as reported by LaRue, S. M. *et al.* (In *Book of Abstracts for the 40th Annual Meeting of the Radiation Research Society*, p. 112, 1992), our study would show that either slowly growing or rapidly growing tumors could be more prone to metastasis.

For most of the comparisons, no significant differences could be established between dogs with and without metastases. However, larger tumor volumes at death appeared to be associated with the probability of metastasis. Only for the comparison of the quartile of the smallest tumor volumes at death with the largest was there a significant difference in the proportion of metastasis ("p" < 0.05). There was no difference identified between adjacent categories of tumor volume. However, the fraction of dogs with metastasis increased monotonically with increasing tumor volume at death for all four quartiles: 1st quartile = 15 metastases in dogs with 53 tumors = 0.208 (mean volume = 2.2 cm^3); 2nd = 0.283 (19.2 cm^3); 3rd = 0.340 (72 cm); and 4th = 0.472 (395 cm^3). According to the nonparametric Kendall rank correlation test, the "p" value for this outcome is 0.042. Therefore, it appears that there is an effect of tumor volume at death on the likelihood of metastasis, with the larger tumors having a greater probability of metastasis than smaller tumors.

Various comparisons of dogs with and without metastases as a function of tumor growth rate did not, for the most part, yield significantly different results between these two groups. The exceptions were when only one tumor per dog was considered for animals having multiple primary tumors (longest doubling time for dogs with metastases and shortest doubling time for dogs without; "p" < 0.001) and when only the tumor with the longest doubling time was included for all dogs with multiple primary tumors ("p" < 0.02). We found that this effect was a result of only two tumors with doubling times of > 45 days. Both had been characterized by Thurman (1971) as among the tumors with the least uncertainty in calculated doubling time. Rates of metastasis in dogs with primary tumors in paired bones, especially the left side, were significantly higher than corresponding values of dogs with primary tumors in unpaired bones. The occurrence of metastases in dogs with primary tumors in the ribs appeared to be more pronounced than those in animals with primary tumors in other bones as compared with the average for the whole skeleton.

We conclude that analysis of the association between a variety of parameters and the occurrence of metastases from radiation-induced bone tumors serves to improve our understanding of the metastatic process. The foregoing analyses also yielded some information about the relative importance of various factors that were expected to influence metastasis.

3. Skeletal Malignancies among Beagle Dogs Injected with ^{241}Am

R. D. Lloyd, G. N. Taylor, W. Angus, S. C. Miller, and B. B. Boecker

Seventy skeletal malignancies were identified in 44 dogs among 117 Beagle dogs injected as young adults with graded dosages of ^{241}Am ranging from about 0.07 to 104 kBq kg^{-1} and maintained for lifetime observation. Sixty-two of these tumors were osteosarcomas; four were fibrosarcomas of bone, and four were chondrosarcomas of bone (Table 39). Of these 117 dogs, 114 survived beyond the minimum age for radiation-induced bone cancer of 2.79 yr, but all are now dead.

Table 39

Dosimetry and Bone Cancer Occurrence Data
in Beagle Dogs Injected with ^{241}Am Citrate

Dose Level	Injected kBq kg^{-1}	No. of Dogs in Study[a]	Dogs with Bone Cancer[b]	Percent ± Uncertainty[c]	Skeletal Dose ± SD 1 yr Before Death, Gy	Age, yr, at Death with Bone Cancer ± SD
Control Dogs						
0	0	132[d]	1	0.76 ± 0.8	—	16.1
Am Dogs						
0.2	0.066 ± 0.002	14	0	0 ± 7.1[e]	0.06 ± 0.02	
0.5	0.197 ± 0.004	14	1[f]	7.1 ± 7.6	0.22 ± 0.05	13.8
1.0	0.58 ± 0.015	25[g]	3[h]	12.0 ± 7.3	0.57 ± 0.13	13.7 ± 1.4
1.7	1.75 ± 0.04	24	10[i]	41.7 ± 13.8	1.49 ± 0.39	11.5 ± 1.4
2.0	3.55 ± 0.06	12	10[j]	83.3 ± 27.5	2.52 ± 0.59	9.1 ± 1.3
3.0	11.3 ± 0.19	13	12	92.3 ± 29.0	4.57 ± 0.87	6.1 ± 0.6
4.0	33.6 ± 4.44	12	8	66.7 ± 22.0	11.2 ± 3.3	5.3 ± 0.5
5.0	104 ± 15	(2)[k]	0		1.84 ± 1.01	
Total (Am dogs)		114[l]	44[m]			

[a] Number that survived at least to 2.79 yr of age, the minimum latent period for death with radiation-induced bone tumor in our dog colony.

[b] All observed tumors were osteosarcomas except as noted.

[c] With one exception, stated uncertainties are geometric means of roughly half of the 95% confidence intervals for the individual groups taken from Table A-5, page 125, of Lilienfeld *et al.* (eds.) (*Cancer Epidemiology: Methods of Study*, The Johns Hopkins Press, Baltimore, MD, 1967).

[d] Plus one additional dog that only lived to 1.81 yr age.

[e] The uncertainty for a group of dogs with zero tumors was taken to be a standard deviation of +1 (Marshall, J. H., ANL-7760, Part II, p. 18, 1970).

[f] One fibrosarcoma of bone plus two separate primary chondrosarcomas of bone, all in the same dog.

[g] Plus one additional dog that lived to only 2.04 yr of age (232 days after injection) and had no bone tumor.

[h] Including one chondrosarcoma of bone plus two fibrosarcomas of bone.

[i] Including one chondrosarcoma of bone.

[j] Including one fibrosarcoma of bone.

[k] Neither dog survived to 2.79 yr of age. Both died without bone tumors.

[l] Plus three dogs that died before 2.79 yr of age without tumors.

[m] Forty-four Am-injected dogs with 70 total bone tumors, eight of which were other than osteosarcomas.

To describe the dependence of percent occurrence of bone sarcoma on skeletal radiation dose, the expression A = 0.76 + 30D was derived where A = percent of dogs with skeletal malignancy within any dosage group, D = average skeletal dose (Gy) at 1 yr before death (for doses < 3 Gy), and 0.76 represents the lifetime percent malignant bone tumor response among 132 suitable control dogs in our colony not given any radioactivity. All dosage groups with skeletal doses of > 3 Gy at a year before death were excluded from the derivation of this expression because they exhibited close to 100% occurrence and appeared to be beyond the region of linearity with dose. Similar analysis of corresponding data for dogs given ^{226}Ra as young adults, excluding the two highest dosage groups in which the bone tumor response was about 100%, yielded the expression, A = 0.76 + 4.7D (D < 20 Gy). The ratio of the coefficients in these two expressions, 6 ± 0.8, indicates the effectiveness for bone cancer induction of ^{241}Am relative to ^{226}Ra (Fig. 34). This compares to the relative effectiveness obtained earlier for a ^{239}Pu to ^{226}Ra ratio of about 16 ± 5 (R. D. Lloyd *et al.* In *Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides*, LMF-130, p. 144, 1991).

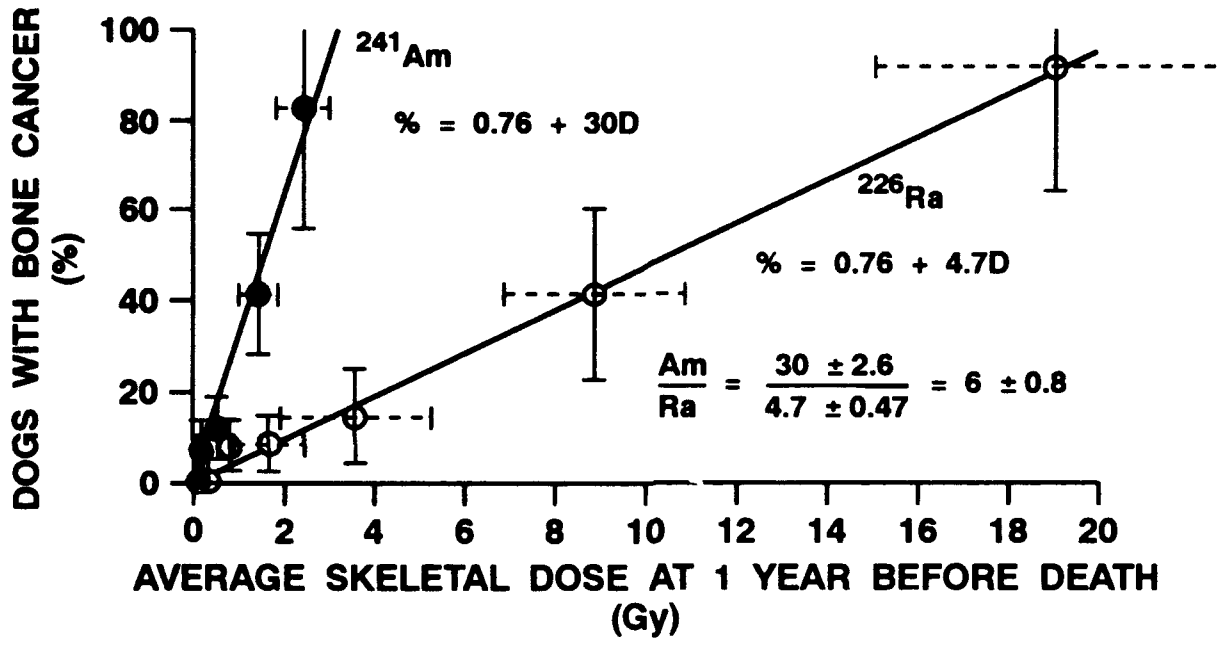

Figure 34. Relative effectiveness for induction of bone malignancies in young adult dogs given either ^{241}Am or ^{226}Ra.

4. Thyroid Lesions Induced by ^{241}Am in the Beagle Dog

G. N. Taylor, R. D. Lloyd, F. W. Bruenger, and S. C. Miller

The concentration of ^{241}Am in the thyroid gland of Beagle dogs, after a single intravenous injection of Am in a citric acid-sodium citrate buffer solution at pH 3.5, was found to be slightly less than the concentration in the liver and moderately greater than in the skeleton (Lloyd, R. D. *et al. Health Phys. 18*: 149, 1970). However, since the mass of the combined thyroid tissue in these dogs was only about 600 mg, the percentage of injected Am retained at this site was relatively low. Part of the impact of this unusually high concentration of ^{241}Am in the thyroid glands of the Beagle dog, with respect to clinical, morphological, and neoplastic changes, is presented in this summary.

All of the dogs observed were purebred Beagles, born and raised at the Radiobiology Laboratory, University of Utah. The ^{241}Am was administered in graded dosages via a single injection in the cephalic vein at about 17 to 18 mo of age (Dougherty, T. F. *et al. Radiat. Res. 17*: 625, 1962). The volume of the injection solution was approximately 8 to 10 mL. Serum thyroxine levels (T4) were determined by radioimmune assay methods, using reagents supplied by PANTEX (Malibu, CA). Autoradiographs were prepared from acetone-fixed, paraffin-embedded tissues. Weighted cumulative tumor rates were determined by the method of Kaplan and Meier (*J. Am. Stat. Assoc. 53*: 457, 1958). Evaluation of statistical significance was by the group comparison ("*t*") test for thyroid weights, analysis of variance for T4 evaluations, and Cox Regression Analysis for thyroid tumor rates.

The percentage of injected activity retained in the thyroid gland following a single intravenous injection was 0.055 ± 0.00066 (mean ± SD), and the percentage remained constant for the range of injected dosages shown in Table 40. Autoradiography indicated that most of the activity was in the basement membranes of the follicles and in the vascular walls of the smaller arterioles. Only small amounts were present in the follicular epithelium or the colloid. The resulting radiation doses (mean ± SD) were 1.4 ± 0.9 and 0.76 ± 0.38 times those delivered to the skeleton and the liver, respectively.

Table 40

Incidence of Thyroid Tumors in Beagle Dogs Given a Single Intravenous Injection of ^{241}Am

^{241}Am Injected (kBq kg^{-1})	Number of Dogs	Average Age[a] at Death (days)	Average Dose to Thyroid (Gy)	Thyroid Tumors[b] (%)	Bone and/or Liver Tumors (%)
101.75	2	941 ± 33	29.8 ± 1.5	0	0
33.58	12	1874 ± 285	28.4 ± 9.2	0	83
11.27	13	2239 ± 220	8.67 ± 4.8	0	92
3.55	12	3327 ± 420	4.04 ± 2.1	0	92
1.74	24	4633 ± 804	2.14 ± 1.2	13	58
0.58	22	4634 ± 804	0.61 ± 0.13	12	45
0.20	14	4906 ± 860	0.25 ± 0.06	0	21
0.07	14	4488 ± 953	0.08 ± 0.02	7	0
(Control)					
0	132	4749 ± 1062	0	11	4

[a]The average age at injection was approximately 505 days.
[b]Includes both benign and malignant tumors.

Characteristic symptoms related to Am-induced thyroid changes, such as lethargy, obesity, epilation, or myxedema were not observed. This was true even in those instances where marked ablation of the gland had produced subnormal levels of serum T4. However, ablation of the thyroids was never absolute, and small islands of follicular cells could be found even in the dogs with the most severe radiation-induced involution.

Evaluation of the average thyroxine (T4) levels in the peripheral blood at various post-injection times indicated functional impairment of the thyroid gland at several Am dosage levels. However, the relatively wide day-to-day variation of the T4 values in both the controls and the irradiated animals made the results of single tests a relatively imprecise index of radiation-induced thyroid injury. The radiation-induced depression of the serum T4 was most clearly evident in the two highest dosage levels studied: 100 and 34 kBq kg^{-1}, which differed significantly from each other and also from the controls ($p < 0.01$; Fig. 35). The T4 values for the 11 kBq kg^{-1} group were similar to those in the controls ($p > 0.20$), even though the radiation-induced histological alterations were usually appreciable. The T4 values of the 3.6, 1.7, and 0.58 kBq kg^{-1} groups were not significantly different from each other ($p > 0.20$) and were grouped together for statistical purposes. Dogs in this combined group had significantly higher T4 levels than either the controls or the 11 kBq kg^{-1} group ($p < 0.01$). This result is consistent with the observed hypertrophy of the follicular epithelium that occurred in a moderate number of these lower dosage animals.

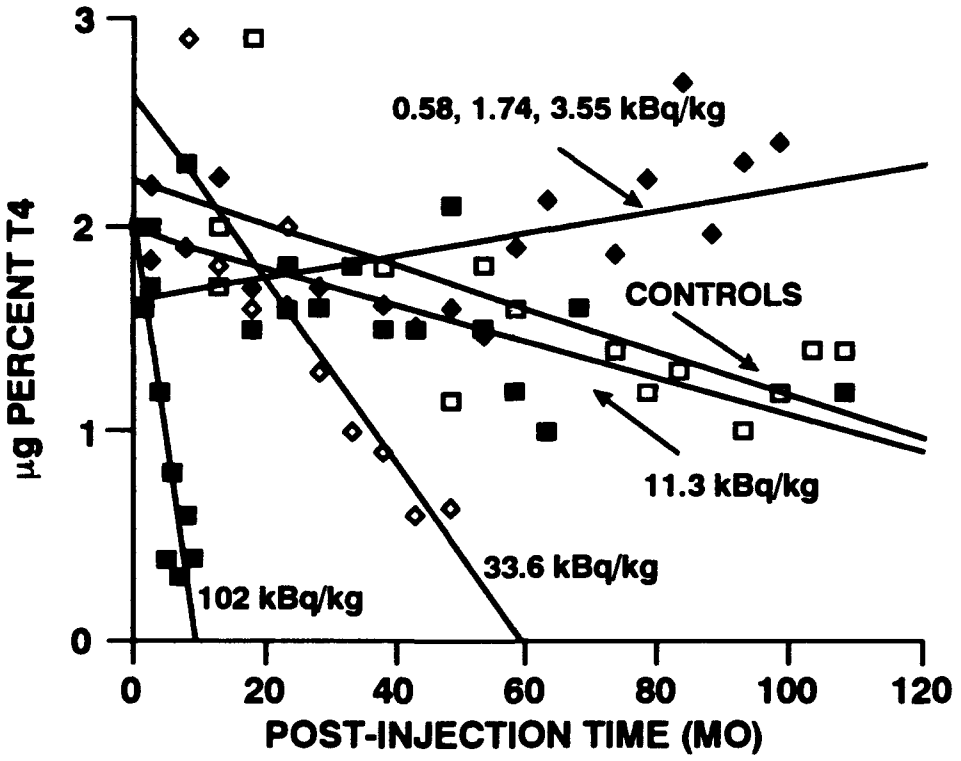

Figure 35. Comparison of T4 values in Beagle dogs injected with various dosage levels of ^{241}Am. The curves are least-squares fits to the plotted points.

Statistically significant ($p < 0.001$) reductions in the thyroid weights occurred in most of the dogs injected at the three highest levels. The most extreme atrophy occurred in the animals given 34 kBq kg^{-1}. Although some variation occurred, the thyroid weights measured in the five lowest dosage levels were within normal limits.

Histologically, in the two dogs injected at the highest dosage level studied, 100 kBq kg^{-1}, and at about 425 days post-injection, the follicular epithelium was mostly low cuboidal and became almost squamous in some areas. Atrophy, degeneration, and necrosis of the epithelium occurred focally. Scattered foci of follicular hyperplasia composed of small clusters of cells and some microfollicles were distributed among the follicles that were present at time of injection. These older follicles were anatomically normal except for the very low

cuboidal epithelium. The epithelium of these such abnormal foci usually exhibited some degree of hypertrophy, indicating that TSH or other stimulation was extant even though much of the older epithelium was nonresponsive. Nearly normal amounts of colloid were present, but based on the low serum T4, metabolic functions in much of the follicular epithelium and colloid compartment were probably impaired to an even greater degree than was suggested by the microscopic appearance. Vascular lesions, interstitial fibrosis, and leukocytic infiltrates were not seen. The absence of extreme anatomical changes at this high dosage level was possibly related to the relatively short survival times. The causes of death at this highest dosage level were combinations of kidney, liver, and bone marrow failure, all sites of high radiation exposure.

Histological changes in the thyroid were most marked in the dogs given 34 kBq kg^{-1}, probably because of the relatively high thyroid dose and the moderately long survival times after injection, averaging 1380 ± 290 days. Follicular atrophy and interstitial fibrosis were invariably present, and loss of follicles and colloid was marked. The glands were frequently reduced to a small fibrotic mass that was sometimes difficult to find at necropsy. Some of the few residual follicles contained hyperplastic foci that were, in some instances, suggestive of an early adenomatous change. These clones of follicular cell hyperplasia occasionally contained microfollicles, generally without colloid. Most of the follicular epithelium in such foci was markedly hypertrophic, suggesting elevated levels of TSH; however, levels of this hormone were not measured in any of the dogs in this study. Cytoplasmic PAS-positive, colloid-like inclusions were present in many of the cells in the hyperplastic foci. Reduced vascularity and hyalinization of some of the arterioles were seen in the most atrophic glands. Focal lymphocytic infiltrates occurred in a few of the animals in this high dosage group but were seldom seen in the other dosage levels.

Marked Am-induced changes also developed in the dogs injected with 11 kBq kg^{-1}. However, compared to the 34 kBq kg^{-1} level, fibrosis was less extreme, the extent of the hyperplasia was greater, and a larger number of colloid-bearing follicles was present. The number of follicles and the amount of colloid appeared adequate for normal function. Follicular hyperplasia and the presence of PAS-positive, colloid-like cytoplasmic inclusions were the most marked of any of the levels. The lesions observed at even lower dosages were principally hypertrophy of the follicular cells and a minor degree of interstitial fibrosis. However, such changes were observed in only some of the animals, and hyperplasia was seldom seen.

A comparison of the incidence of thyroid tumors in the controls with those of the Am-treated dogs is presented in Table 40. Statistical evaluation indicated that the incidence in the control and irradiated dogs was not significantly different ($p > 0.3$). Based on the control population, 6.4 thyroid tumors were expected in the irradiated animals, and seven were observed. The thyroid neoplasms developed mostly in the dogs with long survival times, averaging 11.1 ± 1.8 yr post-injection in the controls and 12.8 ± 2.2 yr in the irradiated groups. The incidence of thyroid tumors in the males was approximately two times that of the females, which contrasts with the higher incidence observed in women (NCRP, *Induction of Thyroid Cancer by Ionizing Radiation*, NCRP, Bethesda Maryland, p. 56, 1985).

In summary, selective deposition of Am that occurred in the thyroid glands of Beagle dogs after a single intravenous injection produced obvious functional and anatomical changes. However, statistically significant increases in the incidence of thyroid neoplasia did not occur.

5. Relationship of Leukemia and Radon or Thoron in the Body

R. D. Lloyd, G. N. Taylor and S. C. Miller

D. L. Henshaw, *et al.* (In *Indoor Radon and Lung Cancer: Reality or Myth?* [F. T. Cross, ed.], Battelle Press, Richland, WA, p. 935, 1992) reported at the Twenty-Ninth Hanford Symposium on Health and the Environment (Oct. 15-19, 1990) that, "... the dose to red bone marrow from radon exceeds all other sources of background radiation ... recent epidemiological data have shown a correlation of domestic radon exposure with several conditions, including leukemia in adults and children ... both acute myeloid and acute lymphatic leukemia are associated with radon exposure ..." This paper was preceded by another publication on the same subject by the same authors (Henshaw, D. L. *et al. The Lancet 335*: 1008, 1990). Other investigators submitted papers to the Hanford conference that seemed to confirm this concept. James, A. C. (In *Indoor Radon and Lung Cancer: Reality or Myth?* [F. T. Cross, ed.], Battelle Press, Richland, WA, p. 167, 1992a) calculated the dose-rates to bone marrow from indoor radon and thoron. Participants in the panel discussion at the conference discussed the possibility that radon and especially thoron could be a radiation hazard to bone marrow. Several of the studies conducted at the University of Utah provide related information on this question. Dogs injected with ^{226}Ra, ^{228}Ra, or ^{228}Th were followed throughout their lifetimes. In all of these dogs, radon (^{222}Rn = Rn) or thoron (^{220}Rn = Tn) was produced continually by the radioactive decay in the skeleton of ^{226}Ra or ^{224}Ra (which is a decay product of ^{228}Th, which in turn is produced by ^{228}Ra). A significant fraction of both these gaseous radionuclides (Rn and Tn) escaped their site of origin in bone, and some was eventually exhaled (Mays, C. W. *et al. Radiat. Res. 8:* 480, 1958a; Mays, C. W. *Radiat. Res. 9*: 438, 1958b). If radon or thoron that is inhaled by humans from ambient air reaches the bone marrow, then a certain amount of the radon or thoron produced by radium decay in the skeleton but not retained in bone also might be expected to irradiate bone marrow. Presuming that all of these suppositions are valid, we anticipated that the experience with regard to these malignancies among our dog colony could confirm the ideas of Henshaw *et al.* (1990; 1992).

There were 205 dogs in our colony given ^{226}Ra and 157 given either ^{228}Ra or ^{228}Th. In addition, we have identified 314 suitable controls (given no radioactivity) that were entered into the experiment during the same period as those given ^{226}Ra, ^{228}Ra, or ^{228}Th. Because the skeletons of the dogs with ^{226}Ra, ^{228}Ra, or ^{228}Th in bone were subjected to radiation from alpha rays (^{228}Ra itself is a beta emitter, but its radioactive daughters, ^{228}Th and ^{224}Ra, emit alpha rays), we thought that it would be appropriate to compare this experience with that of 505 of our dogs given bone-seeking radionuclides that emit alpha rays but have no radioactive gaseous progeny (e. g., ^{239}Pu, ^{241}Am, ^{249}Cf, ^{252}Cf). Among dogs there are a number of malignant conditions that are similar to what is called leukemia in humans and which we believe should be included as leukemia-like diseases (Jarrett, W. F. H. and L. S. Mackey. *Bull. World Health Org. 50*: 21, 1974), so we also investigated their occurrence in the four groups of dogs described above. These included (as myeloid malignancies) myeloid sarcoma, megakaryocytic myelosis, and myeloproliferative disease as well as myelocytic leukemia, and (as lymphoid malignancies) lymphosarcoma–including lymphoma, reticulosarcoma, and lymphocytic leukemia–thymoma, mycosis fungoides, and plasma cell myeloma. Mast cell malignancies were also tabulated.

Table 41 gives the results of our survey. No strong effect of myeloid or lymphoid malignancy or of mast cell malignancy associated with dogs having either radon or thoron in the body appears in these data as compared with control animals or with dogs injected with other alpha-emitting radionuclides ("p" values from the chi-square test were all > 0.05 except for the third line under "C" in Table 41; when corrected for radiation-induced liver tumors, that "p" value was also >0.05). These results do not support the concept of Henshaw *et al.* (1990; 1992).

We believe that if irradiation of bone marrow by radon or thoron was an important causative agent in leukemia induction, at least some effect would have been detected among dogs in our colony. These dogs were irradiated 24 h each day from Rn or Tn continually produced in their skeletons, whereas humans spend only part of their day indoors where radon and thoron concentrations in air are presumably higher than outdoors.

Table 41

Leukemia and Leukemia-Like Diseases Among Beagles Dogs at the University of Utah Dog Colony

(Also included with myeloid malignancies were myeloid sarcoma, megakaryocytic myelosis and myeloproliferative disease as well as myelocytic leukemia and, with lymphoid malignancies, lymphosarcoma–including lymphoma, reticulosarcoma and lymphocytic leukemia–, thymoma, mycosis fungoides and plasma cell myeloma. A tabulation of mast cell malignancies is also shown. "Dogs with Rn" are those injected with ^{226}Ra; "Dogs with Tn" are those injected with ^{228}Ra or ^{228}Th; "Others" are radioactive dogs without Rn or Tn and are those injected with ^{239}Pu, ^{241}Am, ^{249}Cf; "Controls" are those dogs not given any radioactivity.)

	Dogs with Malignancy	Total Dogs	Percent[a]	95% Confidence Limits[b]	
				Lower	Upper
A. Myeloid Neoplasms					
Dogs with Rn	0	205	0.00	–	1.46
Dogs with Tn	1	157	0.64	0.02	3.56
Others	3	505	0.59	0.12	1.72
Controls	1	314	0.32	0.01	1.78
B. Lymphoid Neoplasms					
Dogs with Rn	11	205	5.37	2.68	9.61
Dogs with Tn	8	157	5.10	2.20	10.05
Others	19	505	3.76	2.26	5.87
Controls	16	314	5.10	2.92	8.26
C. Mast Cell Neoplasms					
Dogs with Rn	5	205	2.44	0.79	5.69
Dogs with Tn	3	157	1.91	0.39	5.58
Others	12[c]	505	2.38	1.23	4.16
Controls	3	314	0.96	0.20	2.80
D. Non-Myeloid, Leukemia-Like Diseases (B + C, above)					
Dogs with Rn	16	205	7.80	4.46	12.64
Dogs with Tn	11	157	7.01	3.50	12.55
Others	31	505	6.14	4.14	8.78
Controls	19	314	6.05	3.64	9.44

[a] (Dogs with malignancy divided by total dogs) x 100.

[b] Confidence limits on the percent (see footnote "a"); values taken from Lilienfeld, A. M. *et al.* (In *Cancer Epidemiology: Methods of Study*, The Johns Hopkins Press, Baltimore, MD, p. 125, 1967).

[c] Including six dogs among those given ^{239}Pu or ^{241}Am that were classified as primary liver malignancies and were probably radiation-induced (Taylor, G. N. *et al. Health Phys 61*: 337, 1991). Without these six animals, the percent and 95% confidence limits become, respectively, 1.19, 0.44, and 2.59.

6. Statistics of Hits to Bone Cell Nuclei

I. L. Kruglikov*,**, E. Polig*, and W. S. S. Jee

In this study, the statistics of hits to nuclei of bone-lining cells are being developed. The bone-lining cell is present only during the period of quiescence of the given bone structural unit (BSU). This period of quiescence is the time interval between two remodeling cycles of a BSU, when no cell-mediated resorption occurs in the formation of bone. The stochastic nature of the lifetime of the BSU has been discussed previously (Polig, E. and W. S. S. Jee. *Calcif. Tissue Int. 41*: 130, 1987). For the following, it is assumed that the lifetime of the bone-lining cells, ρ, is identical to the period of quiescence of its associated BSU. The law of remodeling, which was defined for the replacement of BSUs, also governs the fate of the bone-lining cells:

$$g(\delta) = \lambda\delta^{\beta} \quad , \quad \lambda,\beta \geq 0 \, ,$$

where $g(\delta)$ is the conditional probability that a bone-lining cell of age δ disappears within the infinitesimal interval $(\delta, \delta + d\delta)$; λ is a scaling factor dependent on the respective bone turnover rate; and β depends on the time sequence of bone remodeling. Only the stationary situation is considered here, when both the bone turnover rate and the above law of remodeling do not change in time. In general, one can describe the hits to the nuclei of the bone-lining cells as a Poisson process during the random period of quiescence, the distribution of which depends on the law of remodeling.

Let the conditional probability that the number of hits to a bone cell nucleus equals ν, provided the duration of the irradiation interval is ρ, be $\phi(\nu|\rho)$:

$$\phi(\nu|\rho) = \frac{(\alpha\rho)^{\nu}}{\nu!} e^{-\alpha\rho} \, ,$$

where α is the mean hit rate for the given target (Polig, E. *et al. Radiat. Res. 131*: 133, 1992). The conditional expectation $\mathbf{E}\{\nu|\rho\}$ is $\alpha\rho$. The unconditional probability P_{ν} of ν hits is obtained by integration over all possible values of ρ. The unconditional mean number of hits $\bar{\nu}$ to a bone cell nucleus is $\bar{\nu} = \alpha\bar{\rho}$, where $\bar{\rho}$ is the mean quiescence period. Constant irradiation conditions are characterized by a constant parameter α. It is seen that the expectation value $\bar{\nu}$ is independent of the form of the distribution of the quiescence periods. The variance of the number of hits is $\mathbf{Var}\{\nu\} = \mathbf{E}\{\nu^2\} - \mathbf{E}^2\{\nu\} = \alpha^2\mathbf{Var}\{\rho\} + \alpha\bar{\rho}$. The deviation from Poisson statistics is characterized by the relative variance,

$$R_{\nu}(\nu) = \frac{\mathbf{Var}\{\nu\}}{\bar{\nu}} = 1 + \alpha R_{\nu}(\rho) \, ,$$

where $R_{\nu}(\rho) = \mathbf{Var}\{\rho\}/\bar{\rho}$ is the relative variance of the quiescence periods. In the low dose regime ($\alpha\bar{\rho} << 1$), the variation of the number of hits is essentially determined by the Poisson statistics, and in the high dose regime ($\alpha\bar{\rho} >> 1$), it is determined by the variation of the period of quiescence.

In the particular case of random remodeling ($\beta = 0$), there is an exponential distribution of quiescence periods ρ, and the above relationships yield $\mathbf{Var}\{\nu\} = \alpha\bar{\rho}[1 + \alpha\bar{\rho}]$, and $R_{\nu}(\nu) = 1 + \alpha\bar{\rho}$. In the limiting case of deterministic remodeling ($\beta \to \infty$), the lifetime of all cells is constant ($\bar{\rho}$). Thus $\mathbf{Var}\{\nu\} = \bar{\nu} = \alpha\bar{\rho}$, and the relative variance is one. In the general case, the density of the quiescence period ρ follows a Weibull distribution (Polig and Jee, 1987):

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$$f(\rho) = \frac{1}{\mu\rho}\left[\frac{\mu\Gamma(\mu)\rho}{\bar{\rho}}\right]^{1/\mu} \exp\{-\left(\frac{\mu\Gamma(\mu)\rho}{\bar{\rho}}\right)^{1/\mu}\},$$

where $\mu = 1/(\beta + 1)$, and $\Gamma(\mu)$ is the Gamma function. One can show that in the general case, the inequalities $\alpha\bar{\rho} \le \mathrm{Var}\{\nu\} \le \alpha\bar{\rho}[1 + \alpha\bar{\rho}]$, and $1 \le R_{\nu}(\nu) \le 1 + \alpha\bar{\rho}$ hold.

Up to this point, the cells irradiated over the whole quiescence period were considered. The situation for pre-existing cells that experience an instantaneous uptake of an alpha emitter is different. These cells represent the first generation of cells irradiated by a constant hit rate α, with irradiation starting at time t with no previous irradiation. To describe the irradiation of these cells, the residual lifetime γ, which is the interval from t up to the end of the lifetime, is used. Let us consider the general case of age-dependent remodeling when the quiescence periods have a Weibull distribution. In this case, the density distribution of γ is

$$q(z) = \mathrm{Prob}\{z \le \gamma < z+dz\} = \frac{1}{\bar{\rho}} \exp\{-[\frac{z}{\bar{\rho}}\mu\Gamma(\mu)]^{1/\mu}\} .$$

The mean and variance of hits to the nuclei of first generation bone-lining cells are, respectively,

$$\mathbf{E}^{(1)}\{\nu\} = \frac{\alpha\bar{\rho}}{\mu}\Gamma(2\mu)\Gamma^{-2}(\mu) ,$$

$$\mathbf{Var}^{(1)}\{\nu\} = [\Gamma(3\mu)\Gamma^{-2}(2\mu)\Gamma(\mu) - 1]\ [\mathbf{E}^{(1)}\{\nu\}]^2 + \mathbf{E}^{(1)}\{\nu\} ,$$

which yields

$$\frac{1}{2}\alpha\bar{\rho} \le \mathbf{E}^{(1)}\{\nu\} \le \alpha\bar{\rho} ,$$

and

$$\frac{1}{2}\alpha\bar{\rho}(1 + \frac{1}{2}\alpha\bar{\rho}) \le \mathbf{Var}^{(1)}\{\nu\} \le \alpha\bar{\rho}(1 + \alpha\bar{\rho}) .$$

Thus, even for specific values of the mean hit rate α and mean quiescence period $\bar{\rho}$, the law of remodeling significantly affects the values of the mean and variance of hits to the bone-lining cells. For constant turnover rate ($\bar{\rho}$ = constant), the mean number of hits to bone-lining cells of the first generation is two times larger for random remodeling than for deterministic remodeling.

The probabilities of no hits, $P_0(\beta)$, to these cells for random and deterministic remodeling are

$$P_0^{(1)}(\beta=0) = P_0(\beta=0) = \frac{1}{1 + \alpha\bar{\rho}} ,$$

and

$$P_0^{(1)}(\beta=\infty) = \frac{1}{\alpha\bar{\rho}}\{1 - e^{-\alpha\bar{\rho}}\},\ P_0(\beta=\infty) = e^{-\alpha\bar{\rho}} ,$$

respectively. The ranges of possible values of $P_0^{(1)}(\beta)$ and $P_0(\beta)$ for different $\alpha\bar{\rho}$ are shown in Figure 36. For the first generation of the bone cells, age-dependent remodeling gives a higher probability of no hits than does random remodeling. However, for the same $\alpha\bar{\rho}$, the difference is not more than 13.3% of the total number of cells. The highest probability of no hits is attained in the case of deterministic remodeling. For subsequent generations, age-dependent remodeling gives lower probability of no hits than does a random one. For the same $\alpha\bar{\rho}$, the difference is not more than 20.4% of the total number of cells. The highest probability of no hits is attained in the case of random remodeling.

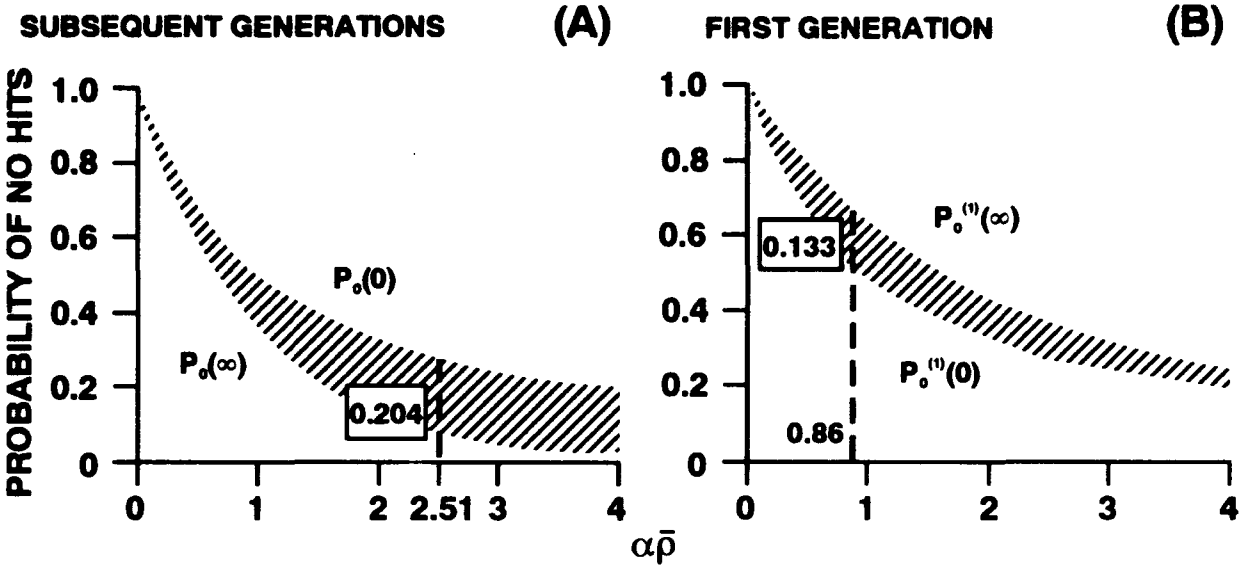

Figure 36. Probability of no hits to the nuclei of bone-lining cells as a function of $\alpha\rho$ for subsequent (A) and first (B) generations of bone cells in the cases of random (P(0)) and deterministic (P(∞)) remodeling.

7. Static and Dynamic Bone Histomorphometry of ^{239}Pu-treated Dogs

W. S. S. Jee, R. B. Setterberg, Y. F. Ma, M. Li, X. G. Liang, F. Johnson, and H. Z. Ke

The first quantitative investigation of local radiation doses and the biological activity at corresponding specific sites of high and low tumor incidence in Beagle dogs was made by Wronski, T. J. *et al.* (*Radiat. Res. 83*: 74, 1980), who determined the micro (i.e., local) distribution of Pu on trabecular surfaces and related the observed changes to the turnover activity at those sites. It was shown that the initial, high concentration of Pu on trabecular surfaces of some high-tumor-incidence sites remained nearly constant for the first month after injection, but declined rapidly between the first and second month, followed by a long period during which the concentration of Pu declined only gradually. Changes in rates of biological activity and Pu concentrations were thought to be caused by an early radiation damage. While this is possible, a more recent view is that the confinement period at the time of injection and subsequent increase in physical activity might be responsible for those changes. In view of this and other possible inconsistencies, it is advisable to compare the early metabolism of low levels of Pu under conditions of confinement and nonconfinement. At the same time, data should be collected on the translocation kinetics of Pu at the local level, and the observed local Pu concentrations should be related to their concentrations in plasma and to the respective biological activities at those sites. This information is necessary for the construction of metabolic-dosimetric models, which, together with data on the chronic toxicity, will form the basis for future risk estimates.

The purpose of this experiment was to provide early detailed dosimetric and biological data on young adult dogs injected with ^{239}Pu under conditions of "Confinement" (in a metabolism cage) and "Nonconfinement" (housed in the kennel facility). Initial gross and local deposition of Pu, its retention and local translocation, and the corresponding biological elements that determine these parameters are being determined to construct appropriate metabolic/dosimetric models for dogs injected with ^{239}Pu. This report deals with our progress in providing data on the turnover of cancellous bone measured as a function of time after exposure.

Fourteen dogs were injected without prior confinement with 0.6 kBq ^{239}Pu per kg and sacrificed sequentially at times ranging from 1 to 64 wk after injection. For comparison, 15 additional dogs were confined for the usual 4-wk period at injection and were sacrificed sequentially in groups of three between 4 wk and 64 wk after injection. All dogs received up to three treatment regimens with fluorescent bone growth markers for the evaluation of bone turnover rates as a function of temporary confinement and nonconfinement.

Forty-micron-thick, undecalcified, plastic-embedded ground sections of the proximal, mid-shaft, and distal humerus, proximal ulna, and second lumbar vertebral body were processed and analyzed (Wronski *et al.*, 1980). The static and dynamic histomorphometry analyses included the percentage of trabecular bone area, trabecular width, number and separation, and bone-volume-based bone formation rate (Frost, H. M. *et al. Metab. Bone Dis. Relat. Res. 2*: 285, 1981; Kimmel, B. A. and W. S. S. Jee. *Anat. Rec. 203*: 31, 1982; Parfitt, A. M. *et al. J. Clin. Invest. 72*: 1396, 1983; Table 42). The current report deals only with data derived from the lumbar vertebral body, distal humerus, and proximal ulna from confined dogs sacrificed at 4, 8, 16, 32, and 64 wk after injection of ^{239}Pu (Table 42). We assume that during the bone labeling period, there was no net gain or loss of bone mass (i.e., bone formation = bone resorption); thus, we used the bone-volume-based bone formation rate as an index of bone turnover.

The data are too limited to draw any definite conclusions, but there are some interesting trends worth mentioning. There are differences in bone mass and architecture (thickness, number, separation, and turnover) among the three bones. The lumbar vertebral body is constructed of less and thinner trabecular bone. Furthermore, it possesses a higher bone formation rate (turnover rate) than the other two bones. Also, in all three bones, the turnover rates are much lower at 4 wk and sometimes at 8 wk than at other times. Again, these data are too preliminary to discuss their significance; that will have to await collection of data from a known site of high cancellous bone turnover (i.e., proximal humerus; Kimmel and Jee, 1982) and from the comparison of the same bones between confined and nonconfined dogs.

Table 42

Bone Histomorphometry of Confined Beagle Dogs

Group	n[a]	Trabecular Bone Area (%)	Trabecular Number (#/mm)	Trabecular Separation (μm)	Trabecular Separation (μm)	Bone Formation Rate/BV[b] (%/yr)
2nd Lumbar Vertebral Body						
4 wk	3	27.3 ± 2.8[c]	100 ± 12.6	2.78 ± 0.23	278 ± 27	118.0 ± 25.3
8 wk	3	29.9 ± 3.8	98 ± 9.0	3.05 ± 0.26	239 ± 29	126.2 ± 25.7
16 wk	3	29.9 ± 1.1	108 ± 8.7	2.78 ± 0.29	265 ± 33	149.5 ± 56.2
32 wk	3	30.7 ± 2.9	109 ± 15.9	2.86 ± 0.16	248 ± 13	190.1 ± 54.8
64 wk	2	28.9 ± 0.1	107 ± 0.7	2.71 ± 0.03	273 ± 13	84.8 ± 2.4
Distal Humerus (DHE2)[d]						
4 wk	3	35.1 ± 4.7	139 ± 20.8	2.54 ± 0.14	256 ± 21	18.9 ± 11.8
8 wk	3	40.6 ± 4.4	184 ± 38.5	2.24 ± 0.30	268 ± 31	102 ± 83.3
16 wk	3	37.9 ± 5.2	154 ± 10.0	2.45 ± 0.26	257 ± 45	93.7 ± 16.1[e]
32 wk	3	41.8 ± 1.7	163 ± 11.0	2.58 ± 0.16	226 ± 17	27.7 ± 21[f]
64 wk	2	45.0 ± 1.1[e]	155 ± 19.0	2.93 ± 0.29[g]	189 ± 15[e,g,h]	55.17 ± 1.0[e,f]
Proximal Ulna (PUA2)[d]						
4 wk	3	46.7 ± 6.7	168 ± 31.8	2.81 ± 0.21	190 ± 20	31.5 ± 13.8
8 wk	3	54.8 ± 8.6	198 ± 30.5	2.78 ± 0.27	164 ± 39	49.8 ± 15.2
16 wk	3	55.0 ± 6.4	212 ± 22.6	2.60 ± 0.23	175 ± 34	66.7 ± 22.0
32 wk	3	51.1 ± 8.4	129 ± 15.8[f]	3.95 ± 0.38[e,f,g]	126 ± 30	44.6 ± 14.4
64 wk	2	46.0 ± 4.1	221 ± 37.7	2.13 ± 0.55[h]	265 ± 88	119.6 ± 85.7

[a]n = number of dogs.
[b]BV = bone volume.
[c]Mean SD.
[d]DHE2 = last 2 cm of distal humerus; PUA2 = 2 cm distal to proximal end of ulna.
[e]$p < 0.05$ vs. 4 wk value.
[f]$p < 0.05$ vs. 16 wk value.
[g]$p < 0.05$ vs. 8 wk value.
[h]$p < 0.05$ vs. 32 wk value.

III. ARGONNE NATIONAL LABORATORY LIFE-SPAN STUDIES IN DOGS

A. SPECIFIC PROJECT OBJECTIVES

Studies have been in progress at the Argonne National Laboratory for many years to study the long-term biological effects of protracted ^{60}Co irradiation in laboratory dogs. Because the dog has a much longer life-span than rodents, results from the dog are providing a bridge for extrapolating results between rodent data and what would be projected for people irradiated under similar conditions. The previously stated objectives of these studies were to (1) determine the relative influence of daily exposure rate and total accumulated dose, (2) provide data for estimates of radiation-specific excess mortality rates in the dog to enable interspecies comparisons with existing rodent data, and (3) study the radiation damage related to life shortening and death, particularly leukemia and other pathology of the blood-forming system. The radiation-exposed dogs in these studies received protracted whole-body ^{60}Co irradiation for 22 h/day, 7 days/wk, at various dose rates down to those allowing a nearly normal life-span. Other dogs that were housed under the same conditions but were not exposed to the ^{60}Co radiation served as controls.

The basic studies initiated at the Argonne National Laboratory to study the effects of protracted whole-body irradiation of dogs have been primarily of two types: life-span and terminated. In the life-span studies, Beagle dogs were entered on study as young adults and irradiated chronically 22 h/day, 7 days/wk, at different dose rates (0.3, 0.75, or 1.9 cGy per day) over their remaining life span. In the terminated-type of study, dogs were chronically exposed under a similar regimen at dose rates of 3.8, 7.5, 12.8, or 26.3 cGy per day until predetermined total doses of 450, 1050, 1500, or 3000 cGy were accumulated. The irradiation of these dogs has been completed or stopped, and most of the dogs are now dead.

B. CURRENT STATUS OF DOGS

The study population alive in January 1991 comprised colony controls, study dogs that were being exposed at the 0.3 cGy per day level and the associated controls. In addition, other dogs were on long-term study of the hematopoietic effects of different regimens of protracted irradiation from an external ^{60}Co source. At that time, a decision was made to discontinue the chronic irradiation of the remaining dogs on study and to transfer all remaining dogs to ITRI for care, clinical observations, and pathological evaluations at death or euthanasia. A total of 73 dogs were transferred to the ITRI colony on January 23, 1991, and are receiving appropriate life-span followup observations (Table 43).

From October 1, 1991, to January 10, 1994, 16 dogs died or were euthanized in the study, *Protracted Whole-Body ^{60}Co Irradiation*. All of the dogs in this study are now dead. Twelve of the 32 dogs transferred to ITRI in this study died with neoplastic disease, a prevalence similar to that of control dogs in the ITRI colony. No clear pattern of site or tumor type emerges from these data. Four dogs died in the *Colony Control* group. One of these dogs died with neoplastic disease. Four dogs in the other studies died. All of the surviving dogs continue to be followed medically, and gross and histopathology information will be obtained at death.

Table 43

Status of Dogs Transferred from Argonne National Laboratory to ITRI on January 23, 1991

Study Name	Tattoo	Sex	Birth Date	Death Date	Death Age	Gross Findings
Protracted Whole-Body ^{60}Co Irradiation 0.3 cGy/day	3020	F	75046	91075	5873	Acute Hepatitis, Nodular Hyperplasia-Liver
	3234	F	76105	91094	5468	Glomerulonephritis, Severe Chronic
	3244	F	76114	91059	5424	Mammary Carcinoma with Metastasis
	3247	M	76114	91104	5469	Congestive Heart Failure, Secondary to Myocardial Degeneration
	3262	M	76119	92365	6090	Perianal Adenocarcinoma, Pyelonephritis, Valvular Insufficiency
	3287	M	76132	91245	5592	Kidney Carcinoma, Metastasis to Adrenal, Thyroid, L. Node
	3300	M	76173	91283	5589	Nasal Tumor, Lip Fibrosarcoma
	3309	M	76174	91309	5614	Kidney Carcinoma, Pyelonephritis, Cystitis, Disseminated Intravascular Coagulation
	3363	M	76292	91350	5537	Chronic Renal Failure, Chronic Heart Failure
	3364	M	76292	91276	5463	Osteosarcoma, Ileum and Leiomyoma Esophagus
	3368	F	76293	92358	5907	Renal Atrophy, Liver Atrophy
	3374	M	76293	93195	6112	Congestive Heart Failure, Renal Insufficiency, Carcinoma Pancreas
	3377	M	76302	91077	5254	Lung-Necrosis, Seizures
	3378	F	76302	91283	5461	Pyelonephritis, Liver Degeneration
	3385	M	76302	93337	6245	Cervical Disc Protrusion
	3410	M	76306	92003	5541	Thyroid Carcinoma, with Metastasis
	3418	M	76308	93126	6028	Intervertebral Disc Protrusion and Spinal Cord Compression
	3432	F	76325	91225	5379	Disc Degeneration, Pyelonephritis, Liver Degeneration
	3433	F	76325	93070	5955	Intervertebral Protrusion and Spinal Cord Compression
	3447	F	76331	91192	5340	Diverse Clinical and Gross Findings, No PCOD Yet
	3456	M	76334	92104	5614	Hydrocephalus, Pheochromocytoma
	3543	M	77164	91303	5252	Intestinal Malabsorption, Neuromuscular Disease

Table 43

Status of Dogs Transferred from Argonne National Laboratory to ITRI on January 23, 1991

Study Name	Tattoo	Sex	Birth Date	Death Date	Death Age	Gross Findings
Protracted Whole-Body ^{60}Co Irradiation 0.3 cGy/day (Concluded)	3544	M	77164	93274	5924	Congestive Heart Failure, Pulmonary Edema
	3549	M	77172	91157	5098	Right Heart Failure, Liver Chronic Passive Congestion, Seizures
	3552	F	77180	92169	5467	Lung - Adenocarcinoma
	3555	F	77180	92199	5497	Renal Cortical Atrophy, Pneumonia
	3571	F	77195	91319	5237	Osteosarcoma, Right Femur, Mammary Gland Adenocarcinoma
	3572	F	77195	91073	4991	Mammary Neoplasia with Metastasis
	3575	F	77195	91204	5122	Myocardial Infarction
	3576	M	77195	91135	5053	Chronic Pyelonephritis
	3590	F	77238	91317	5192	Adenocarcinoma Jejunum
	3602	F	77270	91207	5050	Adrenal Cortical Carcinoma
Hematologic Changes in Radiation-Induced Leukemia	A4171	F	84220			
	4173	M	84220	92087	2789	Squamous Cell Carcinoma Oral Cavity
	A4178	M	84223			
	A4230	M	86034			
	A4231	M	86034			
	A4236	M	86081			
	A4238	M	86081			
	A4239	M	86081			
	A4319	F	86305			
	A4446	M	88044			
	A4449	M	88045			
	A4512	M	89137			
	A4518	M	89138			
	A4524	M	89144			
	A4525	M	89144			
	A4532	M	89148			
	A4535	M	89148			
	A4541	M	89148			
	A4549	M	89187			
	9001	F	81008	92301	4310	Pulmonary Thrombosis, Hepatic Tumor

Table 43

Status of Dogs Transferred from Argonne National Laboratory to ITRI on January 23, 1991

Study Name	Tattoo	Sex	Birth Date	Death Date	Death Age	Gross Findings
Fractionated Weekly Doses from ^{60}Co External Irradiation	A4358	M	87129			
	A4349	M	87123			
	A4405	M	87207			
	4427	M	87343	92129	1612	Bone Marrow Atrophy, Valvular Endocarditis, Embolic Nephritis
Continuous Irradiation *In Utero*	3055	F	75118	92020	6111	Renal Atrophy
	A4147	F	83308			
	A4148	F	83308			
	A4150	F	83308			
Cadmium Metabolism in Dogs	A3917	F	81112	92020	6111	Renal Atrophy
	A9009	F	83185			
Colony Controls	A3542	M	77164			
	A3591	M	77238			
	3618	M	77341	91214	4986	Ruptured Disk, Cord Compression
	3695	F	78171	91144	4721	Ovary-Tumor, Liver-Fibrosarcoma
	3752	M	78179	93210	5510	Pyelonephritis, Renal Atrophy
	3784	M	79127	94003	5355	CNS Disease, Cause Undetermined
	3835	M	79267	92222	4703	Disseminated Malignant Melanoma
	3909	M	81111	92280	4186	Lymphangiotasia Oral Cavity
	A3936	M	81175			
	A3991	M	82005			
	A4161	F	84003			

IV. PUBLICATIONS FROM THE LIFE-SPAN STUDIES IN DOGS AT ITRI

A. OPEN-LITERATURE PUBLICATIONS FROM INCEPTION OF THE ITRI STUDIES THROUGH FY-1991 (Total of 342)

Full references to these publications are given in: *Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides; 1988-1989*, pp. 129-150, Report LMF-128 (1990), *1989-1990*, pp. 157-159, Report LMF-130 (1991), and *1990-1991*, pp. 121-123, Report LMF-135 (1992).

B. OPEN-LITERATURE PUBLICATIONS OF THE ITRI STUDIES DURING FY-1992 AND FY-1993 (Total of 24)

Boecker, B. B., B. A. Muggenburg, F. F. Hahn, K. J. Nikula and W. C. Griffith: Life-Span Health Effects of Relatively Soluble Forms of Internally Deposited Beta-Emitting Radionuclides. In *Proceedings of the International Radiation Protection Association 8th Congress*, pp. 864-867, 1992.

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Davila, D. R., R. A. Guilmette, D. E. Bice, B. A. Muggenburg, D. S. Swafford and P. J. Haley: Long-Term Consequences of $^{239}PuO_2$ Exposure in Dogs: Persistent T Lymphocyte Dysfunction. *Int. J. Radiat. Biol. 61*: 123-133, 1992.

Diel, J. H., R. A. Guilmette, B. A. Muggenburg, F. F. Hahn and I. Y. Chang: Influence of Dose Rate on Survival Time for $^{239}PuO_2$ Induced Radiation Pneumonitis or Pulmonary Fibrosis in Dogs. *Radiat. Res. 129*: 43-60, 1992.

Gillett, N. A., R. R. Pool, G. N. Taylor, B. A. Muggenburg and B. B. Boecker: Strontium-90 Induced Bone Tumours in Beagle Dogs: Effects of Route of Exposure and Dose Rate. *Int. J. Radiat. Biol. 61*: 821-831, 1992.

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Griffith, W. C., B. B. Boecker, F. F. Hahn, B. A. Muggenburg and M. B. Snipes: The Effect of Dose Protraction on the Incidence of Lung Carcinomas in Beagle Dogs with Internally Deposited Beta-Emitting Radionuclides. In *Proceedings of the 8th International Congress of the International Radiation Protection Association*, pp. 896-899, 1992.

Guilmette, R. A. and B. A. Muggenburg: Decorporation Therapy for Inhaled Plutonium Nitrate Using Repeatedly and Continuously Administered DTPA. *Int. J. Radiat. Biol. 63*: 395-403, 1993.

Guilmette, R. A., W. C. Griffith and A. W. Hickman: Intake Assessment for Workers that Inhaled ^{238}Pu Aerosols. To be published in *Proceedings of the Workshop on Intake of Radionuclides: Detection, Assessment and Limitation of Occupational Exposure* held in Bath, UK, September 13-17, 1993 (in press).

Guilmette, R. A. and A. F. Eidson: Using Animal Dosimetry Models to Interpret Human Bioassay Data for Actinide Exposures. *Int. J. Radioanalytical Nucl. Chem. Articles 1561*: 425-449, 1992.

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Hahn, F. F., W. C. Griffith, C. H. Hobbs, B. A. Muggenburg, G. J. Newton and B. B. Boecker: Biological Effects of ^{91}Y in Relatively Insoluble Particles Inhaled by Beagle Dogs. *Ann. Occup. Hyg.* (in press).

Jones, S. E., D. R. Davila, P. J. Haley and D. E. Bice: The Effects of Age on Immune Responses in the Antigen-Instilled Dog Lung. Antibody Responses in the Lung and Lymphoid Tissues Following Primary and Secondary Antigen Instillation. *Mech. Ageing Dev. 68*: 191-207, 1993.

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Shyr, L. J., J. H. Diel, I. Y. Chang and R. A. Guilmette: The Use of Autoradiographic Data for Estimating Tumor Cell Dose in Alpha Immunotherapy. In *Fifth International Radiopharmaceutical Dosimetry Symposium*, pp. 589-599, Oak Ridge Associated Universities, Oak Ridge, TN, 1992.

Taya, A., J. A. Mewhinney, and R. A. Guilmette: Subcellular Distribution of ^{241}Am in Beagle Lungs Following Inhalation of $^{241}Am(NO_3)_3$ Aerosols. *Ann. Occup. Hyg.* (in press).

C. DOCUMENT REPORTS RESULTING FROM THE ITRI STUDIES

Report No.	Date	Title
LF-28	Sep 1965	Selective Summary of Studies on the Fission Product Inhalation Program from July 1964 through June 1965
LF-33	Nov 1966	Selective Summary of Studies on the Fission Product Inhalation Program from July 1965 through June 1966
LF-38	Nov 1967	Fission Product Inhalation Program Annual Report, 1966-1967
LF-39	Nov 1968	Fission Product Inhalation Program Annual Report, 1967-1968
LF-41	Nov 1969	Fission Product Inhalation Program Annual Report, 1968-1969
LF-43	Nov 1970	Fission Product Inhalation Program Annual Report, 1969-1970
LF-44	Nov 1971	Fission Product Inhalation Program Annual Report, 1970-1971
LF-45	Nov 1972	Fission Product Inhalation Program Annual Report, 1971-1972
LF-46	Dec 1973	Inhalation Toxicology Research Institute Annual Report, 1972-1973
LF-49	Dec 1974	Inhalation Toxicology Research Institute Annual Report, 1973-1974
LF-52	Dec 1975	Inhalation Toxicology Research Institute Annual Report, 1974-1975
LF-56	Dec 1976	Inhalation Toxicology Research Institute Annual Report, 1975-1976
LF-58	Dec 1977	Inhalation Toxicology Research Institute Annual Report, 1976-1977
LF-60	Dec 1978	Inhalation Toxicology Research Institute Annual Report, 1977-1978
LF-69	Dec 1979	Inhalation Toxicology Research Institute Annual Report, 1978-1979
LMF-84	Dec 1980	Inhalation Toxicology Research Institute Annual Report, 1979-1980
LMF-91	Dec 1981	Inhalation Toxicology Research Institute Annual Report, 1980-1981
LMF-102	Dec 1982	Inhalation Toxicology Research Institute Annual Report, 1981-1982
LMF-107	Dec 1983	Inhalation Toxicology Research Institute Annual Report, 1982-1983

Report No.	Date	Title
LMF-113	Dec 1984	Inhalation Toxicology Research Institute Annual Report, 1983-1984
LMF-114	Dec 1985	Inhalation Toxicology Research Institute Annual Report, 1984-1985
LMF-115	Dec 1986	Inhalation Toxicology Research Institute Annual Report, 1985-1986
LMF-120	Dec 1987	Inhalation Toxicology Research Institute Annual Report, 1986-1987
LMF-121	Dec 1988	Inhalation Toxicology Research Institute Annual Report, 1987-1988
LMF-128	Aug 1990	Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, 1988-1989
LMF-130	Mar 1991	Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, 1989-1990
LMF-135	Mar 1992	Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, 1990-1991
ITRI-139	Jan 1994	Biennial Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, 1991-1993 (this report)

V. PUBLICATIONS FROM LIFE-SPAN STUDIES IN DOGS AT THE UNIVERSITY OF UTAH

A. OPEN-LITERATURE PUBLICATIONS FROM INCEPTION OF THE UTAH STUDIES THROUGH FY-1991 (Total of 395)

Full references to these publications are given in: *Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides; 1988-1989*, pp. 151-176, Report LMF-128 (1990), *1989-1990*, pp. 163-164, Report LMF-130 (1991), and *1990-1991*, pp. 127-128, Report LMF-135 (1992).

B. OPEN-LITERATURE PUBLICATIONS OF THE UTAH STUDIES DURING FY-1992 and FY-1993 (Total of 20)

Bruenger, F. W., G. Kuswik-Rabiega and S. C. Miller: Decorporation of Aged Actinide Deposits by Oral Administration of Lipophilic Polyaminocarboxylic Acids. *J. Medicinal Chemistry 35*: 112-118, 1992.

Bruenger, F. W., R. D. Lloyd, S. C. Miller, G. N. Taylor and W. Angus: Mammary Tumor Occurrence in Beagles Given ^{226}Ra. (submitted).

Jee, W. S. S., J. Inuoe, K. W. Jee, T. Haba, H. Z. Ke, X. J. Li and R. B. Setterberg: Histomorphometry Assay of Growth Bones. In: *Handbook of Bone Morphology, Second Edition*, H. Takahashi, ed., Nashimura Co. Ltd., Niigata City, Japan, pp. 101-107, 1993.

Lloyd, R. D., W. Angus, G. N. Taylor, G. B. Thurman and S. C. Miller: Occurrence of Metastases in Beagles with Skeletal Malignancies Induced by Internal Irradiation. *Health Phys.* (in press).

Lloyd, R. D., G. N. Taylor and S. C. Miller: Does Leukemia Result from the Presence of Radon or Thoron in the body? *Health Phys. 65*: 439-440, 1993.

Lloyd, R. D., G. N. Taylor, W. Angus, F. W. Bruenger, and S. C. Miller: Bone Cancer Occurrence Among Young Adult Beagles given ^{239}Pu. *Health Phys. 64*: 45-51, 1993.

Lloyd, R. D., G. N. Taylor, W. Angus, F. W. Bruenger and S. C. Miller: Soft Tissue Tumors Among Beagles Injected with ^{226}Ra. (submitted).

Lloyd, R. D., G. N. Taylor, W. Angus, F. W. Bruenger and S. C. Miller: Eye Tumors and Other Lesions Among Beagles Given ^{90}Sr or ^{226}Ra. *Health Phys.* (in press).

Lloyd, R. D., S. C. Miller, G. N. Taylor, F. W. Bruenger, W. S. S. Jee and W. Angus: Relative Effectiveness for Bone Cancer Induction of ^{239}Pu and Some Other Internal Emitters. (submitted).

Lloyd, R. D., G. N. Taylor, W. Angus, S. C. Miller, F. W. Bruenger and W. S. S. Jee: Distribution of Skeletal Malignancies Among Individual Bones of Beagles Given ^{239}Pu Citrate by Intravenous Injection. (submitted).

Miller, S. C. and W. S. S. Jee: Bone Lining Cells. In: *Bone, Vol. 4: Bone Metabolism and Mineralization*, B. K. Hall, ed., CRC Press, Boca Raton, pp. 1-19, 1992.

Miller, S. C., F. W. Bruenger, G. K. Kuswik-Rabiega and R. D. Lloyd: The Decorporation of Plutonium by the Oral Administration of a Partially Lipophilic Polyaminocarboxylic Acid. *Health Phys. 63*: 195-197, 1992.

Miller, S. C., F. W. Bruenger, G. Kuswik-Rabiega, G. Liu and R. D. Lloyd: The Effect of Duration of Treatment and Dose of an Orally Administered, Partially Lipophilic Polyaminocarboxylic Acid on the Decorporation of Plutonium. *J. Pharmacology and Experimental Therapeutics* (in press).

Polig, E., W. S. S. Jee, R. B. Setterberg and F. Johnson: Local Distribution and Dosimetry of ^{226}Ra in the Trabecular Skeleton of the Beagles. *Radiat. Res. 131*: 24-34, 1992.

Polig, E. and W. S. S. Jee: Hit Rates and Radiation Doses to Nuclei of Bone Lining Cells from Alpha-Emitting Radionuclides. *Radiat. Res. 131*: 133-142, 1992.

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Taylor, G. N., R. D. Lloyd, C. W. Mays, W. Angus, S. C. Miller, L. Shabestari and F. F. Hahn: Plutonium or Americium-Induced Liver Tumors in Beagles. *Health Phys. 61*: 337-347, 1991.

Taylor, G. N., R. D. Lloyd, F. W. Bruenger and S. C. Miller: ^{241}Am-Induced Thyroid Lesions in the Beagle. *Health Phys. 64*: 653-660, 1993.

Taylor, G. N., R. D. Lloyd, C. W. Mays, L. Shabestari and S. C. Miller: Promotion of Radiation-Induced Liver Neoplasia by Ethanol. *Health Phys. 62*: 178-182.

Woodard, J. C. and W. S. S. Jee: Skeletal System. In: *Fundamentals of Toxicologic Pathology*, W. M. Haschek-Holik and C. Rorisseau, eds., Academic Press, (in press).

C. DOCUMENT REPORTS RESULTING FORM THE UTAH STUDIES

Report No.	Date	Title
TID-7639	Jun 1954	Consultants Meeting
AECU-3418	Mar 1955	Annual Report
AECU-3109	Sep 1955	Semi-Annual Report
TID-16458	Mar 1956	Annual Report
TID-16459	Sep 1956	Semi-Annual Report
AECU-3522	Mar 1957	Annual Report
AECU-3583	Sep 1957	Semi-Annual Report
COO-215	Mar 1958	Annual Report
COO-216	Mar 1958	Escape of Radon and Thoron
COO-217	Sep 1958	Semi-Annual Report
AECU-4112	Feb 1959	Radioactive Fallout
COO-218	Mar 1959	Annual Report
COO-219	Sep 1959	Semi-Annual Report
COO-220	Mar 1960	Research in Radiobiology
COO-221	Aug 1960	Interim Report of ^{90}Sr
COO-222	Sep 1960	Research in Radiobiology
COO-223	Mar 1961	Research in Radiobiology
COO-224	Sep 1961	Research in Radiobiology
COO-225	Mar 1962	Research in Radiobiology
COO-226	Sep 1962	Research in Radiobiology
COO-227	Mar 1963	Research in Radiobiology
COO-228	Sep 1963	Research in Radiobiology
COO-119-229	Mar 1964	Research in Radiobiology
COO-119-230	Jul 1964	(Superseded by COO-119-245)
COO-119-231	Sep 1964	Research in Radiobiology
COO-119-232	Mar 1965	Research in Radiobiology
COO-119-233	Sep 1965	Research in Radiobiology
COO-119-234	Mar 1966	Research in Radiobiology
COO-119-235	Sep 1966	Research in Radiobiology
COO-119-236	Mar 1967	Research in Radiobiology
COO-119-237	Mar 1968	Research in Radiobiology
COO-119-238	Aug 1968	Rb in RBC, Plasma, and Urine
COO-119-239	Dec 1968	Cs, Rb, and K Metabolism
COO-119-240	Mar 1969	Research in Radiobiology

Report No.	Date	Title
COO-119-241	Mar 1970	Retention and Dosimetry
COO-119-242	Jan 1971	Research in Radiobiology
COO-119-243	Jan 1971	Osteosarcoma Growth Dynamics
COO-119-244	Mar 1971	Research in Radiobiology
COO-119-245	May 1971	(Superseded by COO-119-255)
COO-119-246	Mar 1972	Research in Radiobiology
COO-119-247	Oct 1972	Rb and Cs Metabolism
COO-119-248	Mar 1973	Research in Radiobiology
COO-119-249	Mar 1975	Research in Radiobiology
COO-119-250	Mar 1975	Research in Radiobiology
COO-119-251	Mar 1976	Research in Radiobiology
COO-119-252	Mar 1977	Research in Radiobiology
COO-119-253	Mar 1978	Research in Radiobiology
COO-119-254	Mar 1979	Research in Radiobiology
COO-119-255	Jan 1980	Radiobiology Safety Manual
COO-119-256	Mar 1980	Research in Radiobiology
COO-119-257	Mar 1982	Research in Radiobiology
COO-119-258	Mar 1983	Research in Radiobiology
COO-119-259	Dec 1984	Research in Radiobiology
COO-119-261	Dec 1985	Research in Radiobiology
COO-119-262	Dec 1986	Research in Radiobiology
COO-119-263	Dec 1987	Research in Radiobiology
COO-119-264	Dec 1988	Research in Radiobiology
LMF-121	Dec 1988	ITRI Annual Report
LMF-128	Aug 1990	Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, 1988-1989
LMF-130	Mar 1991	Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, 1989-1990
LMF-135	Mar 1991	Annual Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, 1990-1991
ITRI-139	Jan 1994	Biennial Report on Long-Term Dose-Response Studies of Inhaled or Injected Radionuclides, 1991-1993 (this report)

APPENDIX A: STATUS OF LONGEVITY AND SACRIFICE STUDIES IN BEAGLE DOGS AT ITRI (9/30/93)

Data in this appendix are preliminary estimates through September 30, 1993, of (1) total body or organ contents and (2) the resultant radiation dose received by individual dogs that have been assigned to longevity or sacrifice studies. These estimates are provided as an information source for scientists in this laboratory and others who desire to follow the progress of these studies. It must be emphasized that these data are preliminary and based on results that may be inaccurate or incomplete at the time these tables were prepared. Although the data represent the best information currently available, it must be noted that, with time, certain values and diagnoses will be modified and updated as new and better information becomes available. This information has not, as yet, received the overall vigorous review and analysis by the respective investigators that is required before these data can be used in subsequent analyses. Readers are cautioned against using these data for independent dose-response modeling or other analytical efforts by other scientists until the principal ITRI investigators have had the opportunity to perform the necessary basic data reviews and analyses and publish reports on these studies.

An expedited effort is underway to complete these reviews and publications. When the reviews have been completed and the basic results published in the peer-reviewed literature, the investigators will be very interested in exploring collaborative efforts of mutual interest with other investigators to maximize the ways in which these valuable data are ultimately used.

RADIOACTIVITY CONTENT

Initial body burden (IBB) is defined as the best current estimate of the total radionuclide content within the body immediately after an inhalation exposure or intravenous injection.

Long-term retained burden (LTRB) is defined as the best current estimate of the amount of radionuclide remaining in the body after early clearance of the nasopharyngeal and tracheobronchial regions via the gastrointestinal tract. The term is used in these tables to describe the type of body burden resulting from inhalation of a radionuclide in a relatively soluble form. It is related to the amount of radionuclide deposited in the entire respiratory tract, and not just to the fraction deposited in the pulmonary region.

Initial lung burden (ILB) is defined as the long-term retained burden associated with the inhalation of relatively insoluble particles. In this case, essentially all of the bdy burden remaining after early clearance of the nasopharyngeal and tracheobronchial regions is in the pulmonary region.

CLINICOPATHOLOGICAL FEATURES

Comments are tabulated for the current interpretation of the most prominent clinicopathological features associated with the death of animals. It should be recognized that many animals have multiple tumors or other lesions, not all of which can be listed in a summary table. Diagnoses are discussed in greater detail in the text of this and preceding reports, and in open literature publications.

RADIATION DOSE CALCULATIONS

The methods used in establishing the radiation dose parameters presented have been described in the text of the report or referenced to previous reports. A key consideration in these calculations is tissue weight, because absorbed dose is inversely proportional to tissue weight. Tissue weights used for the calculated dose values reported in Appendix A have changed over the years; it is important that the reader be aware of these changes and the rationale behind them.

Lung weights used in the earliest reported dose calculations (1966-67 Annual Report, LF-38, pp. 19-64 and 1967-68 Annual Report, LF-39, pp. 14-75) were based on a (lung weight)/(body weight) radio of 0.0075 determined from tissue weights from exsanguinated dogs. This ratio was changed to 0.014 in the 1968-69 Annual Report (LF-41, pp. 27-28), based on calculations of the estimated weight of lung with its normal complement of blood in the living dog. Subsequent experimental evidence reported in the 1971-72 Annual Report, (LF-45, pp. 119-128) indicated that this value was too high. Based on these results, our best estimate of the (lung weight (with blood))/(body weight) ratio is 0.011. This value has been used for all dose calculations for dog lungs in all annual report appendices, beginning with those in 1972-73 Annual Report, LF-46.

Liver weights used in early reports were calculated using a (liver weight)/(body weight) ratio of 0.027, which was based on tissue weights from exsanguinated dogs. The ratio was used for dose calculations in all reports through the 1971-72 Annual Report, LF-45. Based on experimental data presented on LF-45, the best estimate for the (liver weight (with blood))/(body weight) ratio is 0.050. This value has been used for all dose calculations for dog liver beginning with the 1972-73 Annual Report, LF-46.

Skeleton weights have always been calculated on the basis of a (skeleton weight)/(body weight) ratio of 0.10.

Tracheobronchial lymph node weights are based on a (tracheobronchial lymph node weight)/(body weight) ratio of 0.00005.

STATUS TABLES

A.1 $^{90}SrCl_2$, Longevity Study

DOG IDENTIFICATION			INHALATION EXP.			I.B.B.			L.T.R.B.			BETA RADIATION DOSE TO SKELETO: DOSE RATE (GY/DAY)				CUM
TATTOO	AN-EXPT	SEX	DATE	AGE DAYS	WT KG	RANK	MBQ/KG	MBQ	RANK	UCI/KG	MBQ/KG	INITIAL	730 DAYS	POTENT.AT 5000 DAYS	AT DEATH	730 DAYS
157E	01-416	F	67115	431	9.7	01	10.	100.	01	120.	4.4	.55	.21	.070	.21	180.
164A	02-419	M	67124	387	9.0	09	7.8	70.	02	120.	4.4	.54		.013	.24	
158E	02-416	F	67115	429	10.2	06	8.9	89.	03	120.	4.4	.54	.16	.053	.15	140.
195C	03-456	F	67275	397	9.3	03	10.	93.	04	110.	4.1	.48			.30	
195B	02-456	M	67275	397	10.1	04	9.6	96.	05	100.	3.7	.48			.34	
162F	01-419	F	67124	436	11.2	02	10.	110.	06	100.	3.7	.47	.21	.037	.20	180.
158B	03-416	M	67115	429	9.3	05	8.9	81.	07	100.	3.7	.47			.36	
159B	02-417	F	67117	430	9.8	08	8.1	78.	08	98.	3.6	.45			.29	
160B	02-418	M	67122	435	9.5	07	8.5	81.	09	97.	3.6	.44	.18	.062	.17	150.
23C	01-261	M	65229	408	9.1	11	5.9	56.	10	83.	3.1	.37	.15	.057	.14	130.
159A	01-417	M	67117	430	11.3	10	6.7	74.	11	74.	2.7	.34			.25	
160C	03-417	F	67117	430	10.4	12	5.9	59.	12	69.	2.6	.31	.075	.032	.068	70.
23B	02-256	M	65208	387	8.0	17	4.1	33.	13	59.	2.2	.27	.081	.023	.059	76.
26F	03-263	F	65231	384	7.8	15	4.4	34.	14	52.	1.9	.24	.090	.037	.064	89.
13A	02-228	M	65123	381	8.3	19	3.7	30.	15	51.	1.9	.23	.066	.019	.054	64.
12F	01-228	F	65123	402	8.1	18	4.1	34.	16	50.	1.9	.26	.086	.045	.080	79.
162A	01-418	M	67122	434	11.9	13	4.8	56.	17	50.	1.9	.23	.095	.023	.060	88.
22E	02-257	F	65209	396	6.7	21	3.4	23.	18	44.	1.6	.20	.047	.015	.024	47.
26A	01-262	M	65230	383	7.8	14	4.4	35.	19	41.	1.5	.19	.064	.024	.053	64.
19B	01-252	M	65201	404	6.4	23	3.1	20.	20	40.	1.5	.18	.038	.013	.021	39.
22F	01-256	F	65208	395	8.8	16	4.4	37.	21	34.	1.3	.16	.062	.026	.051	59.
19C	02-252	F	65201	404	7.8	22	3.2	25.	22	28.	1.0	.13	.033	.014	.019	33.
22A	02-253	M	65202	389	10.5	20	3.6	37.	23	28.	1.0	.12	.061	.015	.035	61.
19D	01-253	F	65202	405	8.7	24	2.6	23.	24	27.	1.0	.12	.034	.013	.021	35.
40E	03-283	F	65301	383	6.3	28	1.0	6.3	25	9.6	0.36	.044	.015	.0061	.0068	15.
28C	02-271	M	65256	406	7.6	26	1.1	8.5	26	9.3	0.34	.043	.014	.0056	.0084	15.
39C	02-283	F	65301	385	8.7	29	1.0	8.5	27	9.1	0.34	.042	.042	.0035	.0035	11.
38E	01-283	F	65301	391	6.5	27	1.1	7.0	28	8.9	0.33	.040	.0081	.0025	.0025	8.4
30C	02-272	M	65257	395	8.5	32	0.70	5.9	29	8.3	0.31	.037	.011	.0033	.0040	12.
30B	01-272	M	65257	395	8.2	35	0.63	5.2	30	7.9	0.29	.036	.0090	.0030	.0032	9.5
42D	01-284	F	65302	377	7.8	30	0.93	7.0	31	7.7	0.28	.036	.011	.0030	.0030	11.
28B	01-271	M	65256	406	7.2	25	1.2	8.5	32	7.1	0.26	.032	.010	.0030	.0050	11.
22D	01-257	M	65209	396	9.1	36	0.59	5.2	33	6.8	0.25	.031	.0088	.0031	.0031	9.3
30D	03-272	M	65257	395	8.9	31	0.85	7.4	34	6.6	0.24	.030	.0091	.0028	.0039	9.3
42E	02-284	F	65302	377	8.7	33	0.70	6.3	35	6.1	0.23	.028	.0083	.0028	.0033	8.3
42F	03-284	F	65302	377	7.3	34	0.63	4.8	36	5.7	0.21	.026	.0059	.0019	.0020	6.7
26B	01-266	M	65238	391	9.0	37	0.24	2.2	37	3.2	0.12	.015	.0041	.00077	.00090	4.1
35E	02-277	F	65271	380	7.5	38	0.20	1.5	38	2.3	0.085	.010	.0033	.0016	.0017	3.5
30G	01-277	F	65271	409	7.0	39	0.17	1.2	39	2.2	0.081	.010	.0037	.0012	.0013	3.8
27D	02-267	F	65239	390	10.6	41	0.15	1.6	40	2.2	0.081	.0098	.0019	.00035	.00039	1.9
27A	03-266	M	65238	389	9.1	43	0.15	1.3	41	1.9	0.070	.0087	.0018	.00047	.00070	1.8
26G	02-266	F	65238	391	7.0	46	0.12	0.81	42	1.9	0.070	.0086	.0019	.00035	.00040	1.8
23E	01-265	M	65237	416	7.8	45	0.12	0.93	43	1.7	0.063	.0079	.0029	.00057	.0016	2.7
24B	03-265	M	65237	397	8.2	42	0.15	1.2	44	1.6	0.059	.0055	.0024	.00074	.00074	2.2
37F	01-282	F	65300	400	8.1	44	0.12	1.0	45	1.1	0.041	.0048	.0019	.00058	.00070	1.9
24A	02-265	M	65237	397	8.0	40	0.16	1.3	46	1.0	0.037	.0047	.0017	.00038		1.7
30E	01-276	M	65270	408	8.1	47	0.10	0.81	47	1.0	0.037	.0046	.0017	.00033	.00035	1.8
30F	02-276	F	65270	408	10.4	48	0.10	1.0	48	0.97	0.036	.0043	.0013	.00031	.00036	1.4

BETA RADIATION DOSE TO SKELETON

...ATE (GY/DAY)			CUMULATIVE (GY)					
...0 ...S	POTENT.AT 5000 DAYS	AT DEATH	730 DAYS	POTENT.TO 5000 DAYS	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENTS
	.070	.21	180.	730. +	190.	69143	759	E-FIBROSARCOMA,PELVIS
	.013	.24		520. +	170.	68344	585	D-EPILEPTIC SEIZURES
	.053	.15	140.	550. +	170.	69311	927	E-HEMANGIOSARCOMA,SITE UNDETERMINED
		.30			8.1	67296	21	D-HEMATOLOGICAL DYSCRASIA
		.34			11.	67303	28	D-HEMATOLOGICAL DYSCRASIA
	.037	.20	180.	610. +	220.	69279	886	E-OSTEOSARCOMA,ILIUM
		.36			13.	67146	31	E-HEMATOLOGICAL DYSCRASIA
		.29			6.6	67135	18	E-HEMATOLOGICAL DYSCRASIA
	.062	.17	150.	620. +	170.	69255	864	E-FIBROSARC.,RIBS;HEMANGIOSARC.,SCAPULA,RIB
	.057	.14	130.	540. +	180.	68233	1099	E-OSTEOSARCOMA,RIB
		.25			8.5	67146	29	D-HEMATOLOGICAL DYSCRASIA
5	.032	.068	70.	280. +	99.	70163	1142	E-HEMANGIOSARCOMA,HUMERUS
1	.023	.059	76.	270. +	150.	70169	1787	E-OSTEOSARCOMA,HUMERUS
9	.037	.064	89.	330. +	180.	70343	1938	E-OST-SARC.,VERT.;HEM-SARC.,RIB AND HAND.
5	.019	.054	64.	220. +	100.	69023	1361	D-CEREBELLAR HEMORRHAGE
5	.045	.080	79.	350. +	100.	68074	1046	E-HEMANGIOSARCOMA,ILIUM
5	.023	.060	88.	320. +	170.	71363	1702	E-OSTEOSARCOMA,MAXILLA
7	.015	.024	47.	160. +	130.	74044	3122	E-OSTEOSARCOMA,VERTEBRAE
5	.024	.053	64.	230. +	100.	69173	1404	D-OSTEOSARCOMA,SACRUM
3	.013	.021	39.	140. +	100.	73243	2964	D-OSTEOSARCOMA,MAXILLA
2	.026	.051	59.	230. +	100.	69287	1540	E-OSTEOSARCOMA,MAXILLA
3	.014	.019	33.	120. +	95.	74151	3237	D-OSTEOSARCOMA,MANDIBLE
1	.015	.035	61.	200. +	130.	71258	2247	E-HEMANGIOSARCOMA,RIB
5	.013	.021	35.	120. +	85.	72279	2633	E-OSTEOSARCOMA,SKULL
5	.0061	.0068	15.	56. +	49.	76278	3994	E-HEPATITIS
5	.0056	.0084	15.	51. +	33.	72136	2436	D-MYELOMONOCYTIC LEUKEMIA
2	.0035	.0035	11.	37.	37.	80084	5261	E-MESOTHELIOMA, PLEURA
31	.0025	.0025	8.4	28.	28.	81135	5678	E-OSTEOARTHRITIS
1	.0033	.0040	12.	39. +	38.	77327	4453	E-LYMPHOSARCOMA
00	.0030	.0032	9.5	32.	32.	78304	4795	D-ADENOCARCINOMA,LUNG
1	.0030	.0030	11.	37.	37.	80263	5439	E-NEPHROSCLEROSIS
0	.0030	.0050	11.	35. +	28.	74046	3077	E-MYXOSARCOMA,MAXILLA
38	.0031	.0031	9.3	31.	31.	80171	5440	D-CONGESTIVE HEART FAILURE
91	.0028	.0039	9.3	32. +	29.	76114	3874	E-HEMANGIOSARCOMA,HEART
33	.0028	.0033	8.3	30. +	27.	76211	3926	D-MALABSORPTION SYNDROME
59	.0019	.0020	6.7	21.	21.	79253	5064	D-HEPATIC DEGENERATION
51	.00077	.00090	4.1	13.	13.	79095	4970	E-TRANSITIONAL CELL CARCINOMA,BLADDER
33	.0016	.0017	3.5	13. +	12.	78107	4584	D-CONGESTIVE HEART FAILURE
37	.0012	.0013	3.8	13.	13.	79085	4927	E-ADENOCARCINOMA, NASAL CAVITY
19	.00035	.00039	1.9	5.7+	5.6	78235	4744	E-EPENDYMOMA,BRAIN
18	.00047	.00070	1.8	6.0+	5.3	75248	3662	E-PERITONITIS
19	.00035	.00040	1.8	5.8	5.8	79204	5079	E-ADENOCARCINOMA, MAMMARY GLAND
29	.00057	.0016	2.7	8.9+	6.1	71293	2247	D-ACCIDENTAL DEATH
24	.00074	.00074	2.2	8.3	8.3	80255	5496	E-NEPHROSCLEROSIS
19	.00058	.00070	1.9	6.6+	6.0	77034	4117	E-BRONCHIOLOALVEOLAR CARCINOMA
17	.00038		1.7	5.4	5.4	81341	5948	E-NEPHROSCLEROSIS
17	.00033	.00035	1.8	5.3+	4.3	74016	3033	D-TRANSITIONAL CELL CARCINOMA,BLADDER
13	.00031	.00036	1.4	4.3+	4.2	78228	4706	E-ADENOCARCINOMA,MAMMARY GLAND

A.1 $^{90}SrCl_2$, Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXP.			I.B.B.			L.T.R.B.			BETA RADIATION DOSE TO SK DOSE RATE (GY/DAY)				
TATTOO	AN-EXPT	SEX	DATE	AGE DAYS	WT KG	RANK	MBQ/KG	MBQ	RANK	UCI/KG	MBQ/KG	INITIAL	730 DAYS	POTENT.AT 5000 DAYS	AT DEATH	7 DA
19A	01-254	M	65203	406	8.7	C			C							
21C	02-254	F	65203	398	8.5	C			C							
24E	01-264	F	65232	392	8.6	C			C							
26E	02-264	F	65232	385	6.9	C			C							
28A	01-273	M	65258	408	9.1	C			C							
30A	03-273	M	65258	396	9.5	C			C							
31A	01-278	M	65272	400	9.1	C			C							
32A	02-278	M	65272	394	8.9	C			C							
33B	03-278	M	65272	388	8.9	C			C							
35F	01-285	F	65305	414	8.1	C			C							
40D	02-285	F	65305	387	9.4	C			C							
42C	03-285	F	65305	380	10.3	C			C							
158A	01-420	M	67115	429	10.2	C			C							
160A	02-420	M	67117	430	9.9	C			C							
162E	03-420	F	67122	434	10.2	C			C							

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE IN

)IATION DOSE TO SKELETON

'DAY)		CUMULATIVE (GY)					
IT.AT DAYS	AT DEATH	730 DAYS	POTENT.TO 5000 DAYS	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENTS
					73021	2740	D-SEPTICEMIA
					78057	4602	D-CONGESTIVE HEART FAILURE
					77357	4508	E-CARCINOMA,THYROID
					80157	5403	D-ASPIRATION PNEUMONIA
					80285	5505	D-CONGESTIVE HEART FAILURE
					75045	3439	E-EPIDERMAL CYST,SKULL
					74008	3023	D-ARTERIOSCLEROSIS;HYPOTHYROIDISM
					77125	4236	E-LYMPHOSARCOMA
					79262	5103	D-LYMPHOSARCOMA
					74030	3012	D-ACCIDENTAL DEATH
					75307	3654	D-ADENOCARCINOMA,MAMMARY GLAND
					79328	5136	D-NEPHROSCLEROSIS
					81009	5008	E-SQUAMOUS CELL CARCINOMA,TONSIL
					82120	5482	E-SQUAMOUS CELL CARCINOMA,TONSIL
					80141	4767	E-PITUITARY ADENOMA-CUSHING'S DISEASE

ENT FINDINGS ARE INCLUDED.

A.2 $^{90}SrCl_2$, Sacrifice Study

DOG IDENTIFICATION			INHALATION EXP.			I.B.B.			L.T.R.B.			BETA RADIATION DOSE TO SKELETON					
												DOSE RATE (GY/DAY)				CUMULAT	
TATTOO	AN-EXPT	SEX	DATE	AGE DAYS	WT KG	RANK	MBQ/KG	MBQ	RANK	UCI/KG	MBQ/KG	INITIAL	730 DAYS	POTENT.AT 5000 DAYS	AT DEATH	730 DAYS	POTEN 5000
7B	01-212	M	65081	407	7.6	03	4.8	37	01	67	2.5	.29	.14	.030	.13	120	43
4C	02-183	M	64325	405	7.4	02	4.8	36	02	65	2.4	.30			.23		
10A	02-215	M	65084	394	10.0	08	3.7	37	03	55	2.0	.22	.10	.022	.086	90	31
8A	02-212	M	65081	402	7.9	01	5.5	44	04	51	1.9	.23	.10	.029	.084	90	34
9D	01-215	F	65084	398	8.9	04	4.8	44	05	47	1.7	.20	.095	.026	.080	84	31
11B	02-216	F	65085	389	9.7	09	3.4	33	06	47	1.7	.25			.17		
2B	01-183	M	64325	411	7.8	06	4.4	33	07	46	1.7	.21		.00001	.063		7
10B	01-216	F	65085	395	7.9	10	3.2	26	08	44	1.6	.20	.071	.017	.046	63	22
9B	01-214	M	65083	397	9.6	17	2.6	26	09	39	1.4	.18	.050	.0087	.038	48	15
9C	02-214	F	65083	397	10.1	15	3.0	30	10	37	1.4	.17	.071	.010	.054	67	20
12E	02-230	F	65125	404	8.4	18	2.6	21	11	36	1.3	.16	.060	.020	.039	56	21
6B	01-207	M	65054	414	7.6	20	2.3	17	12	36	1.3	.13	.044	.019	.021	44	16
5A	02-184	M	64328	391	9.2	07	4.1	37	13	35	1.3	.16		.00029	.072		9
8B	01-213	M	65082	403	8.5	16	2.9	25	14	34	1.3	.16	.051	.017	.034	46	18
4D	01-184	M	64328	408	9.2	11	3.1	29	15	31	1.1	.14			.11		
12B	01-229	F	65124	403	11.0	21	2.2	24	16	30	1.1	.13	.041	.012	.022	39	14
6D	03-207	F	65054	414	7.4	13	3.0	22	17	29	1.1	.14	.043	.014	.024	43	15
12D	01-230	F	65125	404	7.6	14	3.0	23	18	28	1.0	.13		.0034	.054		12
6C	02-207	F	65054	414	8.2	19	2.4	20	19	24	0.89	.11	.040	.012	.017	38	13
9A	02-213	M	65082	396	10.7	22	1.8	19	20	20	0.74	.093	.037	.014	.019	35	13
4B	01-185	M	64329	409	8.8	23	1.7	15	21	16	0.59	.071	.029	.015	.019	28	11
12C	02-229	F	65124	403	9.6	24	1.6	16	22	15	0.55	.068	.023	.0085	.0099	22	8
2A	02-182	M	64324	410	6.8	05	4.4	30	23			.33			.27		
4A	01-182	M	64324	404	9.6	12	3.4	33	24						.13		
5C	03-182	F	64324	387	5.7	C			C								
2D	03-184	F	64328	414	9.9	C			C								
4E	03-183	F	64328	408	7.8	C			C								
6A	04-207	M	65054	414	12.0	C			C								
9E	01-217	F	65083	397	8.2	C			C								
10C	02-217	F	65085	395	8.9	C			C								
12A	01-231	M	65124	403	10.3	C			C								
13B	02-231	M	65124	382	9.6	C			C								
13C	03-231	M	65124	382	8.7	C			C								
13D	04-231	F	65124	382	6.5	C			C								

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLU

DIATION DOSE TO SKELETON.

/DAY)		CUMULATIVE (GY)					
NT.AT DAYS	AT DEATH	730 DAYS	POTENT.TO 5000 DAYS	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
0	.13	120	430+	150.	67279	928	E-HEMANGIOSARCOMA,SCAPULA
	.23			7.3	64353	28	S-
2	.086	90	310+	130.	68157	1168	E-HEMANGIOSARCOMA,SCAPULA
9	.084	90	340+	150.	68348	1362	E-OSTEOSARCOMA,VERTEBRA,SCAPULA
6	.080	84	310+	130.	68305	1316	E-HEMANGIOSARCOMA,THORAX; HUMERUS
	.17			6.0	65116	31	E-HEMATOLOGIC DYSCRASIA
001	.063		72+	39.	65340	381	S-
7	.046	63	220+	140.	70293	2034	D-OSTEOSARC.,SCAPULA & RIB;HEMANGIOSARC.,RIB
87	.038	48	150+	76.	68355	1367	E-FIBROSARCOMA,SKULL
0	.054	67	200+	100.	68306	1318	E-OSTEOSARC.,TIBIA;HEMANGIOSARC.,SITE UNO.
0	.039	56	210+	140.	71314	2380	E-OSTEOSARCOMA,RIB,ILIUM
9	.021	44	160+	130.	75140	3738	E-SQUAMOUS CELL CARCINOMA, NASAL CAVITY
029	.072		96+	36.	65341	379	S-
7	.034	46	180+	110.	71155	2264	E-OSTEOSARCOMA,TIBIA
	.11			3.5	64357	29	S-
2	.022	39	140+	100.	72336	2768	E-OSTEOSARCOMA,ILIUM
4	.024	43	150+	110.	72280	2782	E-OSTEOSARCOMA,MANDIBLE
54	.054		120+	40.	66345	585	D-MYELOMONOCYTIC LEUKEMIA
2	.017	38	130+	110.	74239	3472	E-OSTEOSARCOMA,MANDIBLE
4	.019	35	130+	99.	74028	3233	E-OSTEOSARCOMA,MANDIBLE
5	.019	28	110+	71.	72035	2628	D-BASOSQUAMOUS CARCINOMA,TEMPORAL REGION
85	.0099	22	80+	72.	76329	4222	E-SQUAMOUS CELL CARCINOMA, SINUS CAVITY
	.27			1.5	64329	5	S-
	.13			0.77	64329	5	S-
					64330	6	S-
					65342	380	S-
					64352	24	S-
					78044	4738	E-CARCINOMA,THYROID
					72165	2638	E-FIBROSARCOMA,THORACIC WALL
					75103	3670	D-ADENOCARCINOMA,LUNG
					78162	4786	D-CONGESTIVE HEART FAILURE; NEPHROSCLEROSIS
					72183	2615	D-AUTOIMMUNE HEMOLYTIC ANEMIA
					74147	3310	D-RENAL AMYLOIDOSIS
					79068	5057	E-ADENOCARCINOMA,MAMMARY GLAND

OSURE.

ROMINENT FINDINGS ARE INCLUDED.

A.3 $^{144}CeCl_3$, Longevity Study

DOG IDENTIFICATION			INHALATION EXP.			I.B.B.	L.T.R.B.					BETA RADIATION DOSE T					
												LUNG CUMULATIVE (GY)			LIVER CUMULATIVE (G		
TATTOO	AN-EXPT	SEX	DATE	AGE DAYS	WT KG	MBQ/KG	RANK	UCI/KG	UCI	MBQ/KG	MBQ	365 DAYS	730 DAYS	TO DEATH	365 DAYS	730 DAYS	D
152C	02-407	F	67094	428	8.3	27.	01	360.	2900	13.	110.			210.			2
156B	03-408	M	67096	418	8.6	19.	02	320.	2800	12.	100.			74.			
151B	01-407	M	67094	431	9.8	17.	03	270.	2700	10.	100.			76.			
156D	01-408	F	67096	418	10.0	16.	04	210.	2100	7.8	78.			48.			
198E	01-457	F	67278	392	8.7	15.	05	210.	1800	7.8	67.	170.		170.	280.		2
151C	03-407	F	67094	431	10.0	14.	06	190.	1900	7.0	70.			52.			
197D	02-458	F	67279	393	9.0	13.	07	190.	1700	7.0	63.			52.			
199A	02-462	M	67285	397	8.5	13.	08	190.	1600	7.0	59.			64.			
201G	02-463	F	67290	385	8.3	11.	09	170.	1400	6.3	52.			44.			
153A	02-408	M	67096	430	10.3	10.	10	150.	1500	5.5	56.			86.			
195A	01-458	M	67279	401	10.0	8.9	11	150.	1500	5.5	56.			120.			1
198A	01-462	M	67285	399	8.5	11.	12	140.	1200	5.2	44.	110.	120.	120.	180.	260.	2
203F	03-463	F	67290	377	6.3	13.	13	140.	870	5.2	32.			42.			
197C	03-462	M	67285	399	8.3	9.6	14	130.	1100	4.8	41.			98.			1
200A	02-460	M	67283	390	10.2	7.0	15	120.	1300	4.4	48.	95.		100.	160.		1
199E	01-460	F	67283	395	7.5	12.	16	110.	810	4.1	30.	87.	97.	99.	150.	200.	2
62F	02-322	F	66082	388	9.6	7.4	17	100.	960	3.7	36.	79.	88.	88.	130.	190.	2
201C	03-460	M	67283	378	8.8	10.	18	94.	830	3.5	31.	74.	83.	85.	120.	170.	2
64A	01-326	M	66096	391	9.0	8.1	19	74.	660	2.7	24.	58.	65.	67.	98.	140.	1
60B	01-320	F	66075	402	8.6	4.8	20	69.	590	2.6	22.	55.	61.	62.	91.	130.	1
200E	01-463	F	67290	397	8.3	9.3	21	68.	560	2.5	21.	54.	60.	61.	90.	130.	1
62E	01-322	M	66082	388	8.1	4.8	22	67.	540	2.5	20.	53.	59.	60.	88.	120.	1
64C	03-323	F	66084	379	9.3	5.2	23	55.	520	2.0	19.	43.	48.	50.	73.	100.	1
62B	02-321	M	66080	386	9.9	4.1	24	51.	500	1.9	19.	40.	45.	46.	67.	94.	1
63C	02-323	F	66084	383	6.8	6.3	25	44.	300	1.6	11	35.	39.	39.	58.	81.	
66B	03-326	M	66096	385	8.8	4.4	26	43.	380	1.6	14.	34.	39.	39.	57.	80.	
65B	02-326	M	66096	386	10.9	4.1	27	39.	430	1.4	16.	31.	34.	35.	51.	72.	
61B	01-321	M	66080	396	9.5	2.5	28	31.	300	1.1	11.	24.	27.	28.	41.	57.	
60C	02-320	F	66075	402	10.2	4.8	29	28.	280	1.0	10.	22.	25.	25.	37.	52.	
63B	01-323	M	66084	383	8.1	4.8	30	26.	210	0.96	7.8	21.	23.	23.	34.	48.	
54A	01-305	M	66027	407	10.2	1.6	31	25.	250	0.93	9.3	20.	22.	23.	33.	46.	
54B	02-305	F	66027	407	11.6	1.6	32	24.	280	0.89	10.	19.	21.	22.	32.	44.	
52D	01-302	F	66025	410	7.7	1.6	33	21.	170	0.78	6.3	17.	18.	19.	28.	39.	
55D	02-306	F	66028	407	8.7	1.7	34	17.	150	0.63	5.5	13.	15.	15.	22.	31.	
60D	03-320	F	66075	402	8.8	5.5	35	16.	140	0.59	5.2	13.	14.	14.	21.	30.	
57A	02-308	M	66034	392	8.2	1.3	36	15.	130	0.55	4.8	12.	13.	14.	20.	28.	
53B	02-301	F	66024	409	11.0	1.6	37	14.	150	0.52	5.5	11.	12.	13.	18.	26.	
53C	02-302	F	66025	410	9.0	1.6	38	14.	130	0.52	4.8	11.	12.	13.	19.	26.	
56B	01-308	M	66034	402	10.9	1.3	39	14.	150	0.52	5.5	11.	12.	13.	19.	26.	
52C	01-301	F	66024	409	9.0	1.6	40	13.	120	0.48	4.4	10.	11.	12.	17.	24.	
55A	01-306	M	66028	407	10.8	1.2	41	12.	130	0.44	4.8	9.5	11.	11.	16.	22.	
57C	02-309	M	66035	393	8.2	0.89	42	12.	95	0.44	3.5	9.5	11.	11.	16.	22.	
51B	01-299	M	66021	408	8.4	0.52	43	8.1	68	0.30	2.5	6.4	7.1	7.3	11.	15.	
57B	01-309	M	66035	393	9.3	1.1	44	6.9	64	0.26	2.4	5.5	6.1	6.2	9.1	13.	
50E	03-297	F	66018	411	8.1	0.44	45	6.3	51	0.23	1.9	5.0	5.5	5.7	8.3	12.	
50A	01-297	M	66018	411	8.0	0.48	46	6.2	50	0.23	1.9	4.9	5.5	5.6	8.2	12.	
49A	01-294	M	66013	407	9.9	0.41	47	5.5	55	0.20	2.0	4.3	4.8	5.0	7.3	10.	
52B	02-299	M	66021	406	10.9	0.37	48	5.2	56	0.19	2.1	4.1	4.6	4.7	6.9	9.6	
49B	02-294	M	66013	407	8.8	0.48	49	4.9	43	0.18	1.6	3.9	4.3	4.4	6.5	9.1	
49D	01-295	F	66014	408	10.9	0.41	50	4.7	52	0.17	1.9	3.7	4.1	4.2	6.2	8.7	

ETA RADIATION DOSE TO TISSUE

TO ATH	LIVER CUMULATIVE (GY) 365 DAYS	730 DAYS	TO DEATH	SKELETON CUMULATIVE (GY) 365 DAYS	730 DAYS	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
0.			240.			70.	67238	144	D-PULMONARY INJURY
0.			32.			9.6	67117	21	E-HEMATOLOGICAL DYSCRASIA
0.			41.			12.	67125	31	E-HEMATOLOGICAL DYSCRASIA
0.			21.			6.1	67118	22	E-HEMATOLOGICAL DYSCRASIA
0.	280.		280.	82.		84.	68288	375	D-PULMONARY FIBROSIS
0.			30.			8.6	67125	31	E-HEMATOLOGICAL DYSCRASIA
0.			30.			8.6	67311	32	D-HEMATOLOGICAL DYSCRASIA
0.			44.			13.	67329	44	D-HEMATOLOGICAL DYSCRASIA
0.			22.			6.5	67317	27	D-HEMATOLOGICAL DYSCRASIA
0.			96.			29.	67234	138	D-PULMONARY INJURY
0.			190.			56.	68250	336	D-HEPATIC INJURY
0.	180.	260.	270.	55.	78.	81.	69353	799	E-OSTEOSARCOMA,VERTEBRA
0.			25.			7.4	67326	36	D-HEMATOLOGICAL DYSCRASIA
0.			160.			46.	68229	309	D-HEPATIC INJURY
0.	160.		190.	49.		58.	69062	510	D-MARROW APLASIA
0.	150.	200.	240.	43.	62.	74.	72265	1808	D-HEMANGIOSARCOMA,LIVER;HEPATIC DEGENERATION
0.	130.	190.	200.	39.	56.	60.	68226	874	D-HEPATIC INJURY
0.	120.	170.	210.	37.	53.	63.	72216	1759	E-HEMANGIOSARCOMA,LIVER;HEPATIC DEGENERATION
0.	98.	140.	160.	29.	41.	50.	72069	2164	E-SQUAMOUS CELL CARCINOMA,NASAL CAVITY
0.	91.	130.	150.	27.	39.	46.	70246	1632	E-SQUAM.CELL CARC.,NASAL CAVITY;ADENOMA,LUNG
0.	90.	130.	150.	27.	38.	46.	72247	1783	D-HEMANGIOSARCOMA,LIVER;HEPATIC DEGENERATION
0.	88.	120.	150.	26.	38.	45.	70356	1735	D-HEMANGIOSARCOMA,LIVER;HEPATIC FIBROMA
0.	73.	100.	120.	21.	31.	37.	71064	1806	E-MYELOGENOUS LEUKEMIA
0.	67.	94.	110.	20.	29.	34.	72356	2467	D-HEMANGIOSARCOMA,LIVER;HEPATIC DEGENERATION
0.	58.	81.	97.	17.	29.	29.	78041	4340	E-BILE DUCT CYSTADENOMA,MULTIPLE;HEPATIC DEGEN.
0.	57.	80.	95.	17.	29.	29.	73312	2773	E-SQUAM.CELL CARC.,NASAL CAVITY;CARCINOMA,LUNG
0.	51.	72.	86.	15.	22.	26.	73151	2612	E-HEMANGIOSARCOMA,NASAL CAVITY
0.	41.	57.	68.	12.	21.	21.	75287	3494	D-SQUAMOUS CELL CARCINOMA,NASAL CAVITY
0.	37.	52.	62.	11.	19.	19.	75093	3305	E-MALIGNANT MELANOMA,EAR CANAL; EPENDYMOMA
0.	34.	48.	57.	10.	17.	17.	78326	4625	E-SQ. CELL CARC.,MOUTH;BILE DUCT CYSTADENOMAS,MULT.
0.	33.	46.	55.	9.8	17.	17.	78354	4710	E-NEPHRITIS, BILIARY CYSTS,MULT.;CARC.,PROSTATE
0.	32.	44.	53.	9.4	16.	16.	76351	3976	E-CARCINOMA,MAMMARY GLAND;NODULAR HYPERPLASIA LIVER
0.	28.	39.	46.	8.2	14.	14.	80051	5139	E-CARCINOMA,BLADDER;CARC.,LUNG;CARC.,THYROID
0.	22.	31.	37.	6.6	11.	11.	77062	4052	E-DISC DISEASE;CARC.,THYR. AND ADREN.;BILIARY CYSTS
0.	21.	30.	35.	6.2	11.	11.	77251	4194	E-HEMANGIOSAR.,LIV.;BILIARY CYSTS,MULT.;ADENOMA,PIT.
0.	20.	28.	33.	5.9	8.4	10.	71034	1826	E-MYELOPROLIFERATIVE DISORDER
0.	18.	26.	31.	5.5	9.4	9.4	77064	4058	D-CONGESTIVE HEART FAILURE
0.	19.	26.	31.	5.5	7.8	9.4	78116	4474	E-CARC.,MAM.GLAND;BILE DUCT CYSTADENOMA;HEP. DEGEN.
0.	19.	26.	31.	5.5	7.8	9.4	71019	1811	D-MYELOGENOUS LEUKEMIA
0.	17.	24.	29.	5.1	7.3	8.7	75298	3561	D-ADENOCARC.,MAM.GLAND;SQUA.CELL CARC.,NASAL CAVITY
0.	16.	22.	26.	4.7	6.7	8.0	76070	3694	E-ADENOCARC.,BRONCHOGENIC-LUNG;BILIARY CYSTAD.,MULT.
0.	16.	22.	26.	4.7	6.7	8.0	77102	4085	E-SQUAM.CELL CARC.,NASAL CAVITY
7.3	11.	15.	18.	3.2	4.5	5.4	81027	5485	E-CARCINOMA,LIVER-HEPATOCELLULAR
6.2	9.1	13.	15.	2.7	3.9	4.6	80059	5137	D-CARCINOMA,BILE DUCT
5.7	8.3	12.	14.	2.5	3.5	4.2	74213	3117	D-HEPATIC LIPIDOSIS & DEGENERATION
5.6	8.2	12.	14.	2.4	3.5	4.2	74031	2935	D-EPENDYMOMA, CENTRAL NERVOUS SYSTEM
5.0	7.3	10.	12.	2.2	3.1	3.7	78012	4382	D-MALIGNANT MELANOMA,SOFT PALATE
4.7	6.9	9.6	11.	2.0	2.9	3.5	78279	4641	E-ADENOCARCINOMA, PERIANAL GLAND
4.4	6.5	9.1	11.	1.9	2.7	3.3	80020	5120	D-HEPAT.NOD.HYPERPLASIA;CARC.,THYR.;ASPIRATION PNEU.
4.2	6.2	8.7	10.	1.8	2.6	3.1	79144	4878	E-HEMANGIOSAR.,LIVER;CARC.ADREN.;MULT. BILIARY CYSTS

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A.3 $^{144}CeCl_3$, Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXP.			I.B.B.	L.T.R.B.					BETA RADIATION DOSE TO TI					
												LUNG CUMULATIVE (GY)			LIVER CUMULATIVE (GY)		
TATTOO	AN-EXPT	SEX	DATE	AGE DAYS	WT KG	MBQ/KG	RANK	UCI/KG	UCI	MBQ/KG	MBQ	365 DAYS	730 DAYS	TO DEATH	365 DAYS	730 DAYS	TO DEATH
50F	01-298	F	66020	413	8.3	0.48	51	4.2	35	0.16	1.3	3.3	3.7	3.8	5.5	7.8	9.2
49E	02-295	F	66014	408	9.1	0.37	52	3.9	36	0.14	1.3	3.1	3.4	3.5	5.2	7.2	8.6
51A	02-298	M	66020	407	11.1	0.32	53	3.6	40	0.13	1.5	2.8	3.2	3.2	4.8	6.7	7.9
50D	02-297	F	66018	411	6.9	0.48	54	2.9	20	0.11	0.74	2.3	2.6	2.6	3.8	5.4	6.4
49G	01-296	F	66017	411	8.4	0.28	55	2.6	22	0.096	0.81	2.1	2.3	2.3	3.4	4.8	5.7
49C	01-300	M	66013	407	8.7		C										
50C	02-300	F	66017	410	9.1		C										
51C	03-300	M	66021	408	10.4		C										
51E	04-300	F	66021	408	8.4		C										
52A	05-300	M	66021	406	8.5		C										
53A	01-310	F	66024	409	9.3		C										
53D	02-310	F	66024	409	8.1		C										
54C	03-310	F	66027	407	9.2		C										
56A	04-310	M	66034	402	11.8		C										
60A	01-327	M	66075	402	10.1		C										
61C	02-327	F	66080	396	10.0		C										
62A	03-327	M	66080	386	13.2		C										
153D	01-412	F	67094	428	9.3		C										
156E	02-412	F	67094	416	6.7		C										
197B	01-465	M	67289	403	9.0		C										
198C	02-465	F	67289	403	9.9		C										
201A	03-465	M	67289	384	12.6		C										

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLU

ADIATION DOSE TO TISSUE

LIVER CUMULATIVE (GY)			SKELETON CUMULATIVE (GY)			DEATH DATE	DAYS TO DEATH	COMMENT
365 DAYS	730 DAYS	TO DEATH	365 DAYS	730 DAYS	TO DEATH			
5.5	7.8	9.2	1.6	2.4	2.8	74038	2940	D-MYELOMALACIA
5.2	7.2	8.6	1.5	2.2	2.6	75213	3486	D-PULMONARY EDEMA;NODULAR HYPERPLASIA,LIVER
4.8	6.7	7.9	1.4	2.0	2.4	74309	3211	D-CONGESTIVE HEART FAILURE;HEPATIC DEGENERATION
3.8	5.4	6.4	1.1	1.6	1.9	76358	3992	D-CONG.HEART FAILURE;CHRONIC NEPHRITIS;ADENOMA,MAM.
3.4	4.8	5.7	1.0	1.5	1.7	81036	5498	D-CARCINOMA,PANCREAS;CARCINOMA MAMMARY
						74156	3065	D-ASPIRATION PNEUMONIA,EPILEPSY
						81273	5735	E-RENAL CORTICAL ATROPHY
						76103	3734	D-ANESTHETIC DEATH;HEPATIC DEGENERATION
						79337	5064	E-CARCINOMA,MAMMARY;NEUROFIBROSARCOMA,SUBCUTIS
						76189	3820	D-RENAL AMYLOIDOSIS; UREMIA
						79019	4743	E-CARCINOMA,THYROID;OVARIAN TUMOR
						78073	4432	E-MYELOMALACIA
						80106	5192	E-CARCINOMA,ADRENAL
						80037	5116	E-CARC,LUNG;OLF.NEUROBLASTOMA;SQ.CELL CARC,SAL.GLAND
						82205	5974	D-RENAL ATROPHY AND FIBROSIS
						80333	5366	D-ASPIR.PNEUM.;ADENOCARC.,LUNG;CARC.THY.;CAR.MAMMARY
						73068	2545	E-CARCINOMA,THYROID
						67243	149	S-
						67243	149	S-
						84096	6016	D-VALVULAR INSUFFICIENCY,HEART
						79044	4138	E-MAST CELL TUMOR,SUBCUTIS
						82314	5504	E-INTERSTITIAL NEPHRITIS

T FINDINGS ARE INCLUDED.

A.4 $^{91}YCl_3$, Longevity Study

DOG IDENTIFICATION			INHALATION EXP.			I.B.B.	L.T.R.B.					BETA RADIATION DOSE TO T					
												LUNG CUMULATIVE (GY)			LIVER CUMULATIVE (GY)		
TATTOO	AN-EXPT	SEX	DATE	AGE DAYS	WT KG	MBQ/KG	RANK	UCI/KG	UCI	MBQ/KG	MBQ	365 DAYS	730 DAYS	TO DEATH	365 DAYS	730 DAYS	TO DEATH
118E	02-380	F	66320	413	9.3	48.	01	540	5100	20.	190.			43.			3.4
122C	01-383	M	66333	410	9.8	28.	02	300	3000	11.	110.			28.			3.0
118F	01-382	F	66326	419	8.0	29.	03	290	2300	11.	85.			25.			2.5
119C	01-384	F	66335	423	8.2	20.	04	250	2100	9.3	78.			24.			2.7
164B	01-423	M	67146	409	9.5	16.	05	250	2300	9.3	85.			24.			2.7
119D	02-382	F	66326	414	6.5	27.	06	240	1600	8.9	59.			25.			3.2
123A	02-383	M	66333	409	11.0	33.	07	240	2600	8.9	96.			23.			2.5
118A	01-381	M	66322	415	8.1	20.	08	220	1800	8.1	67.	24.	30.	33.	3.1	8.1	10.
119A	03-381	M	66322	410	8.3	20.	09	220	1800	8.1	67.	24.	30.	33.	3.1	8.1	10.
118D	02-381	F	66322	415	8.6	19.	10	200	1800	7.4	67.	22.	28.	31.	2.8	7.0	9.7
120C	03-384	F	66335	420	9.3	23.	11	200	1900	7.4	70.			20.			2.3
164F	02-423	F	67146	409	9.0	17.	12	200	1800	7.4	67.			20.			2.3
165A	01-426	M	67153	392	11.0	20.	13	160	1700	5.9	63.	18.	23.	24.	2.3	5.9	7.6
171F	02-434	F	67163	391	6.3	26.	14	160	1000	5.9	37.	18.	23.	24.	2.3	5.9	7.6
169C	01-434	M	67163	397	8.7	17.	15	150	1300	5.5	48.	17.	22.	23.	2.1	5.4	7.0
118B	01-380	M	66320	413	7.9	13.	16	140	1100	5.2	41.	15.	19.	20.	1.9	5.1	6.5
120A	02-384	M	66335	420	10.6	20.	17	130	1400	4.8	52.	14.	18.	20.	1.8	4.7	5.9
164C	03-422	M	67144	407	9.3	10.	18	110	1100	4.1	41.	12.	15.	17.	1.6	4.0	5.2
169D	01-432	F	67159	393	5.9	5.2	19	100	610	3.7	23.	11.	14.	15.	1.4	3.6	4.8
164G	01-425	F	67151	414	7.7	6.3	20	94	730	3.5	27.	10.	13.	14.	1.3	3.4	4.5
174A	01-438	M	67172	385	9.6	7.0	21	92	880	3.4	33.	10.	13.	14.	1.3	3.3	4.4
171B	02-435	M	67166	394	9.0	8.5	22	90	820	3.3	30.	9.8	13.	14.	1.2	3.2	4.3
165F	03-426	F	67153	392	9.2	8.1	23	82	750	3.0	28.	9.0	11.	12.	1.1	3.0	3.9
166E	02-426	F	67153	390	11.1	15.	24	73	820	2.7	30.	8.0	10.	11.	1.0	2.6	3.5
172A	03-435	M	67166	385	8.8	6.7	25	68	600	2.5	22.	7.4	9.5	10.	0.97	2.5	3.5
134C	02-385	F	66354	408	9.9	8.5	26	66	650	2.4	24.	7.2	9.3	10.	0.92	2.4	3.1
134A	01-385	M	66354	408	9.7	8.5	27	62	600	2.3	22.	6.7	8.6	9.4	0.86	2.3	3.0
176D	03-438	F	67172	384	9.2	9.3	28	60	550	2.2	20.	6.6	8.4	9.1	0.86	2.2	2.9
169A	01-435	M	67166	400	10.3	8.9	29	58	600	2.1	22.	6.4	8.1	8.9	0.81	2.1	2.8
172C	01-433	F	67160	379	7.1	4.4	30	53	380	2.0	14.	5.8	7.4	8.1	0.76	1.9	2.5
173G	02-433	F	67160	376	7.2	4.8	31	52	370	1.9	14.	5.7	7.2	7.9	0.76	1.9	2.5
174E	02-438	F	67172	385	8.7	7.4	32	51	450	1.9	17.	5.6	7.1	7.7	0.70	1.8	2.4
167B	01-431	M	67158	394	10.5	4.8	33	51	540	1.9	20.	5.6	7.1	7.7	0.70	1.8	2.4
171E	03-429	F	67156	384	6.4	5.2	34	48	310	1.8	11.	5.2	6.7	7.4	0.65	1.7	2.3
165G	02-422	F	67144	383	8.2	3.4	35	46	380	1.7	14.	5.1	6.5	7.0	0.65	1.7	0.20
169B	01-429	M	67156	390	9.9	3.0	36	44	440	1.6	16.	4.8	6.1	6.7	0.59	1.6	2.1
164D	01-422	M	67144	407	9.3	4.8	37	43	400	1.6	15.	4.7	6.0	6.6	0.59	1.6	2.1
176E	01-437	F	67170	382	6.8	5.5	38	41	280	1.5	10.	4.4	5.7	6.2	0.59	1.5	1.9
171A	02-429	M	67156	384	8.2	3.5	39	40	320	1.5	12.	4.3	5.6	6.1	0.54	1.5	1.9
166C	02-425	M	67151	388	11.0	2.4	40	31	350	1.1	13.	3.4	4.3	4.7	0.44	1.1	1.5
174F	02-437	F	67170	383	6.2	3.1	41	16	97	0.59	3.6	1.8	2.3	2.4	0.23	0.59	0.76
167C	04-426	M	67153	389	9.9	2.4	42	14	140	0.52	5.2	1.5	1.9	2.2	0.19	0.51	0.65
118C	01-386	F	66320	413	10.2		C										
119B	02-386	M	66322	410	9.4		C										
121A	04-386	M	66335	416	9.4		C										
164E	01-430	F	67151	414	8.8		C										
165D	02-430	M	67151	390	11.4		C										
165E	03-430	F	67151	390	9.0		C										
166B	04-430	M	67153	390	10.3		C										
167A	01-441	M	67156	392	10.3		C										
167E	02-441	F	67156	392	10.3		C										
171D	03-441	F	67163	391	7.8		C										
174D	04-441	F	67166	379	13.1		C										
176B	05-441	M	67195	407	10.4		C										

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE IN

ADIATION DOSE TO TISSUE

LIVER CUMULATIVE (GY)			SKELETON CUMULATIVE (GY)			DEATH	DAYS TO	
365 DAYS	730 DAYS	TO DEATH	365 DAYS	730 DAYS	TO DEATH	DATE	DEATH	COMMENT
		3.4			9.1	66332	12	D-HEMATOLOGICAL DYSCRASIA
		3.0			8.0	66353	20	D-HEMATOLOGICAL DYSCRASIA
		2.5			6.7	66343	17	E-HEMATOLOGICAL DYSCRASIA
		2.7			7.3	66357	22	D-HEMATOLOGICAL DYSCRASIA
		2.7			7.3	67168	22	D-HEMATOLOGICAL DYSCRASIA
		3.2			8.6	66354	28	D-HEMATOLOGICAL DYSCRASIA
		2.5			6.7	66354	21	D-HEMATOLOGICAL DYSCRASIA
3.1	8.1	10.	8.4	21.	29.	72143	2012	E-SQUAMOUS CELL CARCINOMA, NASAL CAVITY
3.1	8.1	10.	8.4	21.	29.	79137	4563	E-HEPATIC FIBROSIS
2.8	7.0	9.7	7.6	19.	26.	79097	4523	D-CARCINOMA,MAMMARY GLAND
		2.3			6.0	66358	23	E-HEMATOLOGICAL DYSCRASIA
		2.3			6.2	67168	22	D-HEMATOLOGICAL DYSCRASIA
2.3	5.9	7.6	6.1	15.	21.	79074	4304	D-CONGESTIVE HEART FAILURE
2.3	5.9	7.6	6.1	15.	21.	74163	2557	E-SQUAMOUS CELL CARCINOMA, NASAL CAVITY
2.1	5.4	7.0	5.7	14.	20.	77202	3692	E-LYMPHOMA, VISCERA
1.9	5.1	6.5	5.3	13.	18.	78261	4324	E-RIGHT HEART FAILURE
1.8	4.7	5.9	4.9	12.	17.	78038	4086	E-NEPHROSCLEROSIS
1.6	4.0	5.2	4.2	11.	14.	68252	473	D-EPILEPTIC SEIZURE
1.4	3.6	4.8	3.8	9.6	13.	80344	4933	E-CONGESTIVE HEART FAILURE
1.3	3.4	4.5	3.6	9.0	12.	73217	2258	D-SARCOMA, MAST CELL
1.3	3.3	4.4	3.5	8.8	12.	79061	4272	D-CARCINOMA,LUNG
1.2	3.2	4.3	3.4	8.6	12.	79114	4331	E-UREMIA
1.1	3.0	3.9	3.1	7.9	11.	80032	4627	D-HEMANGIOSARCOMA,LIVER
1.0	2.6	3.5	2.8	7.0	9.5	81065	5026	D-DISSEMINATED CARCINOMA
0.97	2.5	3.5	2.6	6.5	8.8	82085	5398	E-PROSTATITIS
0.92	2.4	3.1	2.5	6.3	8.6	76054	3352	E-SQ.CELL CARC,NASAL CAV.;HEM.SARC.,UNDET.SITE
0.86	2.3	3.0	2.4	6.0	8.1	81007	5132	D-CONGESTIVE HEART FAILURE
0.86	2.2	2.9	2.3	5.8	7.8	79356	4567	D-PULMONARY INFARCTION
0.81	2.1	2.8	2.2	5.6	7.5	68165	364	D-EPILEPTIC SEIZURE
0.76	1.9	2.5	2.0	5.1	6.9	78257	4115	E-CHEMODECTOMA
0.76	1.9	2.5	2.0	5.0	6.8	80134	4722	E-CARCINOMA,MAMMARY GLAND
0.70	1.8	2.4	1.9	4.9	6.6	81175	5117	D-RENAL FAILURE
0.70	1.8	2.4	1.9	4.9	6.6	83066	5752	E-CARCINOMA,ORAL CAVITY
0.65	1.7	2.3	1.8	4.6	6.2	77117	3614	D-DISSEMINATED CARCINOMA,MAMMARY GLAND
0.65	1.7	0.20	1.7	4.4	6.0	78223	4097	E-AMELOANOTIC MELANOSARCOMA, MOUTH
0.59	1.6	2.1	1.7	4.2	5.7	78025	3887	D-AUTOIMMUNE HEMOLYTIC ANEMIA
0.59	1.6	2.1	1.6	4.1	5.6	82300	5635	D-ENTERITIS
0.59	1.5	1.9	1.6	3.9	5.3	80288	4866	E-LEIOMYOMA, VAGINA
0.54	1.5	1.9	1.5	3.8	5.2	79165	4392	E-RENAL FAILURE
0.44	1.1	1.5	1.2	3.0	4.0	79172	4404	D-CELLULITIS
0.23	0.59	0.76	0.61	1.5	2.1	74276	2663	D-GLOMERULONEPHRITIS; RENAL FAILURE
0.19	0.51	0.65	0.53	1.3	1.8	81160	5121	D-BRONCHOPNEUMONIA
						81296	5455	E-ADENOCARCINOMA,MAMMARY GLAND
						80024	4815	E-CARCINOMA,THYROID
						81132	5276	E-OSTEOARTHRITIS
						77203	3705	E-DISSEMINATED CARCINOMA,MAMMARY GLAND
						79134	4366	E-HEMANGIOSARCOMA,LIVER
						78279	4146	D-HEPATIC DEGENERATION
						81195	5156	E-HEMANGIOSARCOMA,PERITONEUM
						73205	2241	D-SUPPURATIVE PLEURITIS
						81226	5184	E-CARCINOMA,STOMACH
						78187	4042	D-CONGESTIVE HEART FAILURE
						78107	3959	E-GASTROENTERITIS
						81190	5109	D-INTERSTITIAL NEPHRITIS

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ENT FINDINGS ARE INCLUDED.

A.5 $^{91}YCl_3$, Sacrifice Study

DOG IDENTIFICATION			INHALATION EXP.			I.B.B.	I.L.B.					BETA RADIATION DOSE TO TISSUE: LUNG CUMULATIVE (GY)			LIVER CUMULATIVE (GY)			CU
TATTOO	AN-EXPT	SEX	DATE	AGE DAYS	WT KG	MBQ/KG	RANK	UCI/KG	UCI	MBQ/KG	MBQ	30 DAYS	120 DAYS	TO DEATH	30 DAYS	120 DAYS	TO DEATH	30 DAY
173F	02-442	F	67179	395	9.1	9.6	01	220	1000	8.1	37	24	30	33	5.7	15	19.	8.4
172B	01-442	M	67179	398	7.2	19.	02	220	1600	8.1	59			23			5.3	
176C	01-443	F	67180	392	8.3	14.	03	170	1500	6.3	56	19		19	4.4		4.8	6.5
174C	02-443	M	67180	393	7.9	11.	04	120	970	4.4	36	13	17	18	3.1	8	11.	4.4

UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLU

ION DOSE TO TISSUE

LIVER CUMULATIVE (GY)		SKELETON CUMULATIVE (GY)			DEATH DATE	DAYS TO DEATH	COMMENT
120 DAYS	TO DEATH	30 DAYS	120 DAYS	TO DEATH			
15	19.	8.4	21	29.	73096	2109	D-BRONCHIOLOALVEOLAR CARCINOMA;CARCINOMA,MAMMARY
	5.3			7.5	67206	27	D-HEMATOLOGICAL DYSCRASIA
	4.8	6.5		6.8	67213	33	D-HEMATOLOGICAL DYSCRASIA
8	11.	4.6	12	16.	81021	4955	E-ENCEPHALOPATHY

FINDINGS ARE INCLUDED.

A.6 ^{137}CsCl, Longevity Study

DOG IDENTIFICATION			INJECTION EXPOSURE				I.B.B.					RADIATION DOSE TO WHOL				
												DOSE RATE (GY/DAY)				
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	30 DAYS	180 DAYS	365 DAYS	AT DEATH
271D	12-558	F	F	68330	421	7.2	01	4000	29000	150	1100	.72				.31
244B	06-522	M	A	68164	402	8.8	02	3900	34000	140	1300	.72	.31			.30
241F	06-523	F	B	68165	419	8.2	03	3900	32000	140	1200	.71				.38
273A	11-558	M	E	68330	405	9.4	04	3800	36000	140	1300	.69				.43
269D	06-540	M	D	68215	422	10.1	05	3600	36000	130	1300	.68				.35
253C	06-539	F	C	68214	393	9.5	06	3500	33000	130	1200	.65				.38
277F	09-560	F	H	68354	392	7.1	07	3000	21000	110	780	.54	.19	.0020	.00002	
284B	09-562	M	I	69028	394	8.5	08	2900	25000	110	930	.52	.18	.0020	.00001	
282C	10-562	F	J	69028	402	7.6	09	2900	22000	110	810	.53	.25	.0059	.00020	
280C	09-567	F	L	69052	429	7.9	10	2900	23000	110	850	.53				.32
292A	10-567	M	K	69052	379	8.5	11	2900	25000	110	930	.52	.17	.0030	.00003	
241G	05-523	F	B	68165	419	8.6	12	2800	24000	100	890	.51				.27
247E	05-539	F	C	68214	428	7.9	13	2800	22000	100	810	.51				.27
266C	09-558	M	E	68330	435	7.4	14	2800	21000	100	780	.50	.23	.0025	.00005	
273E	10-558	F	F	68330	405	8.3	15	2800	23000	100	850	.51	.26	.0075	.00030	
245B	05-522	M	A	68164	392	9.1	16	2700	25000	100	930	.51	.18			.051
279D	10-560	M	G	68354	383	8.1	17	2700	22000	100	810	.48	.22	.0050	.00010	
248A	05-540	M	D	68215	428	9.6	18	2600	25000	96	930	.48	.23	.0030	.00003	
244E	04-523	F	B	68165	403	7.5	19	2100	16000	78	590	.37	.16	.0035	.00004	
266D	08-558	F	F	68330	435	7.8	20	2100	16000	78	590	.37	.15	.0020	.00005	
279B	07-560	M	G	68354	383	9.9	21	2000	20000	74	740	.36	.19	.0060	.00020	
275E	08-560	F	H	68354	410	7.8	22	2000	16000	74	590	.37	.15	.0020	.00003	
283D	08-562	F	J	69028	395	8.8	23	2000	18000	74	670	.37	.13	.0025	.00004	
292C	08-567	F	L	69052	379	9.0	24	1900	17000	70	630	.36	.14	.0040	.00008	
241A	04-522	M	A	68164	418	10.0	25	1900	19000	70	700	.36	.18			.090
271A	07-558	M	E	68330	421	9.8	26	1900	19000	70	700	.35	.19	.0040	.00010	.000003
283A	07-562	M	I	69028	395	11.2	27	1900	21000	70	780	.35	.14	.0030	.00005	
291A	07-567	M	K	69052	382	10.8	28	1900	21000	70	780	.35	.12	.0028	.00003	
253B	04-539	F	C	68214	393	9.7	29	1800	17000	67	630	.34	.15	.0040	.00006	
247A	04-540	M	D	68215	429	9.8	30	1800	18000	67	670	.34	.17	.0060	.00010	
244C	03-522	M	A	68164	402	6.7	31	1600	11000	59	410	.28	.090	.0013	.00001	
280D	06-562	F	J	69028	405	6.8	32	1600	11000	59	410	.28	.098	.0025	.00003	
279A	05-560	M	G	68354	383	9.5	33	1500	14000	56	520	.27	.11	.0011	.00002	
278F	06-560	F	H	68354	391	8.4	34	1500	13000	56	480	.26	.13	.0030	.00010	
286D	05-567	F	L	69052	417	8.8	35	1500	13000	56	480	.27	.10	.0022	.00004	
241E	03-523	F	B	68165	419	9.4	36	1400	13000	52	480	.26	.14	.0050	.00015	
267A	05-558	M	E	68330	435	11.2	37	1400	16000	52	590	.26	.15	.0060	.00020	
268C	06-558	F	F	68330	433	11.0	38	1400	15000	52	560	.26	.17	.014	.00060	
289D	05-562	M	I	69028	376	9.7	39	1400	14000	52	520	.26	.099	.0030	.00005	
247C	03-540	M	D	68215	429	8.8	40	1300	11000	48	410	.25	.12	.0018	.00003	
291C	06-567	M	K	69052	382	7.7	41	1200	9200	44	340	.22	.11	.0041	.00005	
252C	03-539	F	C	68214	407	9.3	42	1200	11000	44	410	.21	.12	.0025	.00005	
244F	02-523	F	B	68165	403	5.8	43	1100	6400	41	240	.20	.072	.00083	.00001	
278B	04-560	M	G	68354	391	9.5	44	1100	10000	41	370	.21	.10	.0020	.00003	
241B	02-522	M	A	68164	418	9.8	45	1000	9800	37	360	.19	.079	.0013	.00001	
273F	04-558	F	F	68330	405	8.4	46	1000	8400	37	310	.19	.10	.0045	.00040	
278D	03-560	F	H	68354	391	10.3	47	1000	10000	37	370	.19	.084	.0013	.00004	
281C	04-562	F	J	69028	404	8.4	48	1000	8400	37	310	.19	.065	.0015	.00006	
281B	03-567	F	L	69052	428	9.8	49	940	9200	35	340	.17	.081	.0030	.00008	
285A	03-562	M	I	69028	393	10.5	50	920	9700	34	360	.17	.063	.0020	.00002	
287A	04-567	M	K	69052	410	10.2	51	900	9200	33	340	.17	.080	.0028	.00007	

RADIATION DOSE TO WHOLE BODY

E (GY/DAY)			CUMULATIVE (GY)						
80 YS	365 DAYS	AT DEATH	30 DAYS	180 DAYS	365 DAYS	AT DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
		.31				11.	68356	26	D-HEMATOLOGICAL DYSCRASIA
		.30	13.			14.	68197	33	D-HEMATOLOGICAL DYSCRASIA
		.38				10.	68187	22	D-HEMATOLOGICAL DYSCRASIA
		.43				9.5	68349	19	D-HEMATOLOGICAL DYSCRASIA
		.35				13.	68242	27	D-HEMATOLOGICAL DYSCRASIA
		.38				9.7	68236	22	D-HEMATOLOGICAL DYSCRASIA
20	.00002		9.2	15.	15.	15.	80094	4123	E-RENAL INFARCTION
20	.00001		9.0	15.	15.	15.	81182	4537	D-CARCINOMA,PROSTATE
59	.00020		10.	20.	20.	20.	73271	1704	E-ARTHRITIS;PNEUMONIA
		.32				9.1	69076	24	E-HEMATOLOGICAL DYSCRASIA
30	.00003		7.9	15.	15.	15.	81146	4477	E-CARC.,NASAL CAVITY;CARC.,INTESTINE
		.27				8.6	68190	25	D-HEMATOLOGICAL DYSCRASIA
		.27				9.1	68241	27	D-HEMATOLOGICAL DYSCRASIA
25	.00005		9.5	17.	17.	17.	73097	1594	D-PNEUMONIA;PHARYNGITIS
75	.00030		10.	22.	22.	22.	77343	3301	E-SUPPURATIVE ENDOMETRITIS
		.051	8.6			14.	68245	81	D-HEMATOLOGICAL DYSCRASIA
50	.00010		9.5	18.	18.	18.	76139	2707	E-SARCOMA, MAST CELL
30	.00003		10.	19.	19.	19.	77313	3386	E-SQUAM. CELL CARCINOMA,SINUS CAVITY
35	.00004		7.0	15.	15.	15.	80022	4240	E-NEPHROSCLEROSIS;CARCINOMA, LUNG
20	.00005		6.7	12.	12.	12.	77204	3162	D-CONGESTIVE HEART FAILURE
60	.00020		7.8	15.	15.	15.	79262	3926	E-TUMOR, PERIPHERAL NERVE
20	.00003		7.0	12.	12.	12.	83013	5138	D-MAMMARY ADENOCARCINOMA
25	.00004		6.4	11.	11.	11.	80322	4311	D-HEMATOMA,SPLEEN
40	.00008		6.7	12.	12.	12.	77277	3147	D-HEMANGIOSARCOMA,HEART
		.090	7.1			13.	68241	77	D-HEMATOLOGICAL DYSCRASIA
40	.00010	.000003	7.3	15.	15.	15.	70292	693	D-SHOCK
30	.00005		7.3	12.	12.	12.	80286	4275	D-HEMANGIOSARCOMA,SPLEEN
28	.00003		6.3	10.	10.	10.	80077	4042	E-LEUKOENCEPHALOMALACIA
40	.00006		6.5	13.	13.	13.	80265	4434	D-CARCINOMA,MAMMARY GLAND
60	.00010		7.2	15.	15.	15.	80280	4448	D-HEPATIC DEGENERATION
13	.00001		4.3	7.7	7.7	7.7	82091	5041	D-HEPATIC ATROPHY
25	.00003		5.0	8.4	8.5	8.5	80128	4117	E-CARCINOMA,MAMMARY GLAND
11	.00002		4.7	8.3	8.4	8.4	74310	2148	D-RENAL AMYLOIDOSIS
30	.00010		5.6	10.	10.	10.	83173	5298	D-INTERSTITIAL NEPHRITIS
22	.00004		4.8	8.2	8.3	8.3	79184	3784	D-PYOMETRA
50	.00015		5.5	12.	12.	12.	82195	5144	D-HEMANGIOSARCOMA,LIVER
60	.00020		5.8	13.	13.	13.	78206	3529	E-BRAIN EDEMA,UNDETERMINED CAUSE
6	.00060		6.3	15.	15.	15.	81334	4753	D-HEPATIC ATROPHY
50	.00005		4.8	8.7	8.8	8.8	79312	3936	E-CARCINOMA,NASAL CAVITY
18	.00003		4.7	9.8	9.9	9.9	81327	4861	D-CARCINOMA,STOMACH
41	.00005		5.2	9.7	9.9	9.9	83090	5151	E-RENAL CORTICAL FIBROSIS
25	.00005		4.8	9.5	9.7	9.7	80072	4241	E-SARCOMA,MAMMARY GLAND
083	.00001		3.4	5.9	5.9	5.9	80120	4338	D-RENAL AMYLOIDOSIS
20	.00003		4.4	8.1	8.2	8.2	79269	3933	E-TUMOR, LIVER
13	.00001		3.3	6.4	6.5	6.5	83027	5342	E-PYELONEPHRITIS
65	.00040		4.2	8.8	9.1	9.1	81266	4685	E-CARCINOMA,MAMMARY GLAND
13	.00004		3.5	6.4	6.5	6.5	82217	4977	E-MEDIASTINAL TUMOR
15	.00006		3.2	5.6	5.7	5.7	81282	4637	D-CNS DISTURBANCE
10	.00008		3.5	6.9	7.1	7.1	80046	4011	D-CARCINOMA,MAMMARY;TUMOR, NASAL CAVITY
10	.00002		3.1	5.4	5.5	5.5	82028	4748	E-CARCINOMA,BLADDER
18	.00007		3.6	6.7	6.9	6.9	75332	2471	E-NEUROFIBROSARCOMA,LIVER

A.6 ^{137}CsCl, Longevity Study (continued)

DOG IDENTIFICATION			INJECTION EXPOSURE				I.R.B.					RADIATION DOSE TO WHOLE BO DOSE RATE (GY/DAY)					
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	30 DAYS	180 DAYS	365 DAYS	AT DEATH	30 DAYS
249C	02-540	M	D	68215	422	8.8	52	900	7900	33	290	.17	.086	.0022	.00002		3.4
266A	03-558	M	E	68330	435	9.1	53	890	8100	33	300	.16	.079	.0015	.00004		3.3
248C	02-539	F	C	68214	427	8.3	54	880	7300	33	270	.16	.076	.0011	.00002		3.3
241C	01-522	M	A	68164	418	9.7	C										
244D	01-523	F	B	68165	403	7.2	C										
251D	01-539	F	C	68214	408	6.8	C										
247B	01-540	M	D	68215	429	9.4	C										
267D	02-558	F	F	68330	435	7.4	C										
270B	01-558	M	E	68330	423	8.4	C										
274E	01-560	F	H	68354	419	7.1	C										
277A	02-560	M	G	68354	392	9.4	C										
282A	01-562	M	I	69028	402	8.6	C										
283C	02-562	F	J	69028	395	8.8	C										
282D	02-567	F	L	69052	426	6.9	C										
286C	01-567	M	K	69052	417	8.4	C										

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLUD

'ION DOSE TO WHOLE BODY

'DAY)		CUMULATIVE (GY)						
365 DAYS	AT DEATH	30 DAYS	180 DAYS	365 DAYS	AT DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
00002		3.4	7.0	7.1	7.1	81015	4549	E-CARCINOMA,BLADDER
00004		3.3	6.3	6.4	6.4	81056	4475	E-HEMANGIOSARCOMA,SPLEEN
00002		3.3	6.1	6.1	6.1	80318	4487	E-LIVER DEGEN.;CARC.,LIVER;CARC.,LUNG
						82313	5263	E-INTERSTITIAL NEPHRITIS
						70081	647	D-HEMOLYTIC ANEMIA;ENDOCARDITIS
						83054	5319	E-INTERSTITIAL NEPHRITIS
						84233	5862	E-PYELONEPHRITIS
						79225	3913	D-ENDOMETRITIS; PERITONITIS
						83364	5513	D-ADENOCARCINOMA,PROSTATE
						77154	3088	D-CARCINOMA,MAMMARY GLAND
						75239	2442	D-RENAL AMYLOIDOSIS
						84130	5580	E-THROMBOSIS,AORTA
						85199	6015	D-BRONCHIOLOALVEOLAR CARC.,LUNG
						78030	3265	E-RENAL FAILURE;UREMIA
						82011	4707	E-PYELONEPHRITIS

'T FINDINGS ARE INCLUDED.

A.7 ^{90}Y in Fused Aluminosilicate Particles, Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					BETA RADIATION DOSE T		
					AGE	WT								RATE (GY/MIN)		CUMULA
TATTOO	AN-EXPT	SEX	BLOCK	DATE	DAYS	KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	AT DEATH	INFIN.
333A	02-661	M	A	69266	415	10.3	230.	2300	01	5200	53000	190.	2000	.15	.030	810+
333T	01-661	F	B	69266	415	8.6	180.	1600	02	3600	31000	130.	1100	.10	.005	570+
347S	02-684	F	D	69322	379	9.8	130.	1300	03	2800	27000	100.	1000	.080		440
340C	03-684	M	C	69322	419	10.6	130.	1400	04	2600	28000	96.	1000	.076		410
332V	01-662	F	B	69267	418	5.5	150.	850	05	2400	13000	89.	480	.060		370
339A	04-684	M	C	69322	422	9.8	89.	850	06	1900	19000	70.	700	.056		300
335S	03-661	F	B	69266	399	9.7	96.	930	07	1900	18000	70.	670	.055		290
334A	04-661	M	A	69266	406	11.4	85.	960	08	1700	19000	63.	700	.048		270
341T	03-685	F	D	69323	417	9.0	93.	810	09	1700	15000	63.	560	.048		270
340U	01-684	F	D	69322	419	9.8	170.	1700	10	1600	16000	59.	590	.048		250
341C	02-685	M	C	69323	417	10.1	67.	670	11	1500	15000	56.	560	.044		240
340B	05-685	M	C	69323	420	10.6	63.	670	12	1400	15000	52.	560	.042		230
334B	02-662	M	A	69267	407	10.6	70.	740	13	1400	15000	52.	560	.041		230
332T	04-662	F	B	69267	418	8.0	70.	560	14	1400	11000	52.	410	.041		220
347B	04-685	M	C	69323	380	8.5	56.	480	15	1300	11000	48.	410	.038		200
335A	03-662	M	A	69267	400	9.6	59.	560	16	1100	11000	41.	410	.032		180
343V	01-685	F	D	69323	395	7.1	96.	670	17	1100	7500	41.	280	.030		170
406U	04-820	F	H	70258	409	8.4	52.	440	18	1100	8800	41.	330	.030		170
339S	05-662	F	B	69267	367	7.7	67.	520	19	1000	7800	37.	290	.029		170
406A	03-820	M	G	70258	409	12.0	56.	670	20	980	12000	36.	440	.027		150
448U	02-874	F	L	71089	411	8.4	67.	560	21	900	7600	33.	280	.027		140
439A	03-863	M	I	71053	402	13.1	48.	630	22	850	11000	31.	410	.024		140
343C	03-686	M	C	69325	397	9.3	32.	300	23	760	7100	28.	260	.022		120
437T	01-863	F	J	71053	406	7.6	30.	230	24	740	5600	27.	210	.022		120
380B	01-746	M	E	70124	394	9.0	36.	320	25	730	6600	27.	240	.022		120
451B	04-874	M	K	71089	401	9.5	41.	370	26	730	6900	27.	260	.022		120
403T	02-820	F	H	70258	416	6.9	34.	230	27	710	4900	26.	180	.020		110
449U	01-874	F	L	71089	408	5.9	44.	260	28	710	4200	26.	160	.020		110
452B	03-874	M	K	71089	401	9.8	41.	410	29	700	6900	26.	260	.020		110
341S	02-686	F	D	69325	419	9.8	35.	340	30	690	6800	26.	250	.020		110
413A	01-821	M	G	70259	383	11.2	29.	320	31	680	7600	25.	280	.020		110
333B	06-662	M	A	69267	416	11.9	36.	440	32	680	8000	25.	300	.019		110
448B	04-863	M	I	71053	375	9.8	31.	310	33	670	6600	25.	240	.019		100
402C	01-820	M	G	70258	417	7.0	29.	200	34	660	4700	24.	170	.019		100
404U	03-821	F	H	70259	416	5.9	32.	190	35	640	3700	24.	140	.019		100
434T	02-863	F	J	71053	415	7.3	30.	220	36	640	4700	24.	170	.019		100
446C	03-864	M	I	71054	380	11.2	25.	280	37	600	6700	22.	250	.018		95
436U	01-864	F	J	71054	412	9.1	34.	310	38	590	5300	22.	200	.018		93
371S	03-746	F	F	70124	423	7.8	25.	190	39	590	4600	22.	170	.018		93
400T	04-821	F	H	70259	426	6.5	21.	130	40	500	3300	19.	120	.015		79
378B	04-746	M	E	70124	410	10.3	26.	260	41	490	5100	18.	190	.014		77
333S	02-663	F	B	69268	417	7.6	22.	160	42	460	3500	17.	130	.014		72
450B	03-875	M	K	71090	406	9.4	21.	200	43	450	4200	17.	160	.013		71
446S	04-864	F	J	71054	380	8.1	21.	170	44	420	3400	16.	130	.012		66
332C	01-663	M	A	69268	419	8.5	19.	160	45	410	3500	15.	130	.012		65
449S	04-875	F	L	71090	409	7.9	21.	160	46	400	3200	15.	120	.012		64
400U	01-817	F	H	70251	418	7.6	20.	150	47	400	3000	15.	110	.012		62
411C	02-821	M	G	70259	394	9.2	21.	190	48	380	3500	14.	130	.011		60
439C	02-864	M	I	71054	403	9.7	26.	250	49	380	3700	14.	140	.011		60
411D	04-817	M	G	70251	386	9.8	16.	150	50	380	3700	14.	140	.011		60
452A	01-875	M	K	71090	402	9.6	20.	190	51	380	3600	14.	130	.011		60
449T	02-875	F	L	71090	409	8.2	20.	160	52	380	3100	14.	110	.011		60

.B.			BETA RADIATION DOSE TO LUNG						
			RATE (GY/MIN)		CUMULATIVE (GY)				
:I	MBQ/KG	MBQ	INITIAL	AT DEATH	INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
00	190.	2000	.15	.030	810+	700	69273	7	D-PULMONARY INJURY
00	130.	1100	.10	.005	570+	550	69278	12	D-PULMONARY INJURY
00	100.	1000	.080		440	440	70004	47	D-PULMONARY INJURY
00	96.	1000	.076		410	410	69353	31	D-PULMONARY INJURY
00	89.	480	.060		370	370	69342	75	D-PULMONARY INJURY
00	70.	700	.056		300	300	70021	64	D-PULMONARY INJURY
00	70.	670	.055		290	290	69336	70	D-PULMONARY INJURY
00	63.	700	.048		270	270	69304	38	E-PULMONARY INJURY
00	63.	560	.048		270	270	70033	75	D-PULMONARY INJURY
00	59.	590	.048		250	250	70045	88	D-PULMONARY INJURY
00	56.	560	.044		240	240	70043	85	D-PULMONARY INJURY
00	52.	560	.042		230	230	70048	90	D-PULMONARY INJURY
00	52.	560	.041		230	230	69290	23	D-PULMONARY INJURY
00	52.	410	.041		220	220	69356	89	E-PULMONARY INJURY
00	48.	410	.038		200	200	70033	75	D-PULMONARY INJURY
00	41.	410	.032		180	180	69358	91	D-PULMONARY INJURY
00	41.	280	.030		170	170	70050	92	D-PULMONARY INJURY
00	41.	330	.030		170	170	70349	91	D-PULMONARY INJURY
00	37.	290	.029		170	170	69349	82	D-PULMONARY INJURY
00	36.	440	.027		150	150	71001	108	D-PULMONARY INJURY
00	33.	280	.027		140	140	71230	141	D-PULMONARY INJURY
00	31.	410	.024		140	140	71158	105	D-PULMONARY INJURY
00	28.	260	.022		120	120	70077	117	D-PULMONARY INJURY
00	27.	210	.022		120	120	71175	122	D-PULMONARY INJURY
00	27.	240	.022		120	120	70323	199	D-PULMONARY INJURY
00	27.	260	.022		120	120	71232	143	D-PULMONARY INJURY
00	26.	180	.020		110	110	71028	135	D-PULMONARY INJURY
00	26.	160	.020		110	110	73261	903	D-PULMONARY FIBROSIS;ADENOMA,LUNG
00	26.	260	.020		110	110	71210	121	D-PULMONARY INJURY
00	26.	250	.020		110	110	70123	163	E-PULMONARY INJURY
00	25.	280	.020		110	110	71108	214	D-PULMONARY INJURY
00	25.	300	.019		110	110	70028	126	D-PULMONARY INJURY
00	25.	240	.019		100	100	77139	2278	E-FIBROSARCOMA,LUNG;OSTEOPATHY
00	24.	170	.019		100	100	71356	463	D-PULMONARY INJURY
00	24.	140	.019		100	100	71114	220	D-PULMONARY INJURY
00	24.	170	.019		100	100	71176	123	D-PULMONARY INJURY
00	22.	250	.018		95	95	71291	237	D-PULMONARY INJURY
00	22.	200	.018		93	93	71259	205	D-PULMONARY INJURY
00	22.	170	.018		93	93	70306	182	D-PULMONARY INJURY
00	19.	120	.015		79	79	79172	3200	D-CONGESTIVE HEART FAILURE
00	18.	190	.014		77	77	77194	2627	E-BRONC.ALV.CARC.;OSTEOSARC.,VERT.
00	17.	130	.014		72	72	75327	2250	D-BRONCHIOLOALVEOLAR CARCINOMA
00	17.	160	.013		71	71	80131	3328	D-CARCINOMA,LUNG
00	16.	130	.012		66	66	77239	2377	E-CARCINOMA;SITE UNDETERMINED
00	15.	130	.012		65	65	78013	3032	E-SQUAMOUS CELL CARCINOMA,LUNG
00	15.	120	.012		64	64	84295	4953	D-CONGESTIVE HEART FAILURE
00	15.	110	.012		62	62	83010	4507	E-ADENOCARCINOMA,MAMMARY
00	14.	130	.011		60	60	80118	3511	D-HEART FAILURE
00	14.	140	.011		60	60	80178	3411	E-HEART FAILURE
00	14.	140	.011		60	60	81247	4014	D-LYMPHOSARCOMA,LIVER
00	14.	130	.011		60	60	82146	4074	E-ORAL MELANOSARCOMA
00	14.	110	.011		60	60	82036	3964	E-MAMMARY CARCINOMA

A.7 ^{90}Y in Fused Aluminosilicate Particles, Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					BETA RADIATION DOSE TO LUN	
					AGE	WT								RATE (GY/MIN)	CUMULATIVE
TATTOO	AN-EXPT	SEX	BLOCK	DATE	DAYS	KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL AT DEATH	INFIN. TO D
374T	02-746	F	F	70124	414	8.0	17.	140	53	370	3000	14.	110	.011	58
348C	04-686	M	C	69325	376	8.7	25.	210	54	360	3200	13.	120	.011	57
343T	01-686	F	D	69325	397	8.5	16.	140	55	360	3100	13.	110	.011	57
434S	01-867	F	J	71055	417	9.4	16.	150	56	340	3200	13.	120	.0096	53
407S	02-817	F	H	70251	402	7.2	16.	120	57	320	2300	12.	85	.0093	51
380D	01-747	M	E	70125	395	9.4	15.	140	58	300	2900	11.	110	.0090	48
406B	03-817	M	G	70251	402	12.1	18.	210	59	300	3600	11.	130	.0088	48
446D	04-867	M	I	71055	381	11.4	17.	190	60	300	3400	11.	130	.0088	48
375U	02-747	F	F	70125	415	7.6	14.	110	61	290	2200	11.	81	.0088	48
437S	03-867	F	J	71055	408	8.4	16.	130	62	280	2300	10.	85	.0080	44
441A	02-867	M	I	71055	399	9.0	13.	110	63	270	2400	10.	89	.0079	43
399A	02-818	M	G	70252	422	9.0	10.	93	64	260	2300	9.6	85	.0075	41
377B	03-747	M	E	70125	412	9.0	13.	110	65	250	2300	9.3	85	.0072	39
450C	01-876	M	K	71091	407	10.4	10.	100	66	250	2600	9.3	96	.0072	39
339U	04-687	F	D	69328	428	7.2	12.	85	67	240	1700	8.9	63	.0069	38
372S	04-747	F	F	70125	423	9.6	12.	110	68	230	2200	8.5	81	.0069	36
339B	01-687	M	C	69328	428	9.1	8.5	78	69	230	2100	8.5	78	.0065	36
332S	03-663	F	B	69268	419	8.6	10.	89	70	220	1900	8.1	70	.0065	36
447U	04-876	F	L	71091	414	6.6	10.	67	71	220	1500	8.1	56	.0065	34
335B	04-663	M	A	69268	401	9.8	10.	100	72	190	1900	7.0	70	.0056	30
408U	01-818	F	H	70252	395	9.0	9.6	89	73	190	1700	7.0	63	.0056	30
438S	01-868	F	J	71056	405	9.1	16.	150	74	190	1800	7.0	67	.0055	30
447B	03-868	M	I	71056	379	7.3	11.	78	75	180	1300	6.7	48	.0052	28
377S	01-748	F	F	70126	413	9.9	7.0	70	76	150	1500	5.5	56	.0043	24
380C	03-748	M	E	70126	396	10.2	6.7	70	77	140	1500	5.2	56	.0043	23
339T	02-665	F	B	69269	369	6.4	7.0	44	78	130	830	4.8	31	.0038	20
407B	03-818	M	G	70252	403	10.6	7.0	74	79	130	1300	4.8	48	.0037	20
450E	03-876	M	K	71091	407	10.2	6.3	63	80	130	1300	4.8	48	.0037	20
448T	02-876	F	L	71091	413	8.3	5.2	44	81	120	960	4.4	36	.0033	19
343A	03-687	M	C	69328	400	9.3	4.4	41	82	110	1000	4.1	37	.0033	18
405U	04-818	F	H	70252	403	6.8	5.5	37	83	110	720	4.1	27	.0030	17
334C	01-665	M	A	69269	409	8.3	5.2	44	84	100	850	3.7	31	.0030	17
436V	04-868	F	J	71056	414	7.4	6.7	48	85	100	750	3.7	28	.0029	15
438B	02-868	M	I	71056	405	8.6	5.5	48	86	98	840	3.6	31	.0028	15
379B	02-748	M	E	70126	402	10.7	4.1	44	87	90	960	3.3	36	.0027	14
372T	04-748	F	F	70126	424	10.4	3.4	36	88	83	860	3.1	32	.0023	13
340T	02-687	F	D	69328	425	10.2	3.7	41	89	80	810	3.0	30	.0023	13
333E	01-660	M	A	69265	414	9.5			C						
334T	02-660	F	B	69265	405	8.5			C						
348S	02-683	F	D	69321	372	9.0			C						
349B	01-683	M	C	69321	372	12.2			C						
378A	01-745	M	E	70121	407	11.6			C						
383U	02-745	F	F	70121	375	6.0			C						
401A	02-812	M	G	70247	413	9.2			C						
407T	01-812	F	H	70247	398	8.0			C						
438U	02-862	F	J	71050	399	7.8			C						
441B	01-862	M	I	71050	394	8.6			C						
447W	02-873	F	L	71085	408	6.6			C						
448A	01-873	M	K	71085	407	10.0			C						

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLU

BETA RADIATION DOSE TO LUNG

RATE (GY/MIN)		CUMULATIVE (GY)		DEATH	DAYS TO	
INITIAL	AT DEATH	INFIN.	TO DEATH	DATE	DEATH	COMMENT
.011		58	58	81195	4089	D-PULMONARY FIBROSIS;CARCINOMA,LUNG
.011		57	57	84213	5366	E-BRONCHIOLOALVEOLAR CARCINOMA,LUNG
.011		57	57	80231	3923	D-HEMOLYTIC ANEMIA
.0096		53	53	82295	4258	D-CONGESTIVE HEART FAILURE
.0093		51	51	83062	4559	E-INTERSTITIAL PNEUMONIA
.0090		48	48	79189	3351	D-UREMIA
.0088		48	48	80197	3598	D-INTERSTITIAL PNEUMONIA
.0088		48	48	81124	3722	E-LYMPHOSARCOMA,LIVER
.0088		48	48	83341	4964	E-ADENOCARCINOMA,MAMMARY GLAND
.0080		44	44	84221	4914	E-ADENOCARCINOMA,NASAL
.0079		43	43	86013	5437	E-CARCINOMA,LUNG
.0075		41	41	81290	4056	D-RENAL TUMORS
.0072		39	39	85254	5608	E-HEMANGIOSARCOMA,MUSCLE
.0072		39	39	84164	4821	D-SQUAMOUS CELL CARCINOMA,TONSIL
.0069		38	38	80325	4014	E-ADENOCARCINOMA,MAMMARY GLAND
.0069		36	36	83084	4707	D-ADENOCARCINOMA,JEJUNUM
.0065		36	36	81263	4318	D-RENAL AMYLOIDOSIS
.0065		36	36	85089	5665	E-CARCINOMA,LUNG
.0065		34	34	82209	4136	D-EPILEPSY
.0056		30	30	80293	4042	D-MENINGIOMA
.0056		30	30	82105	4236	E-PITUITARY TUMOR
.0055		30	30	82134	4096	E-LYMPHOSARCOMA
.0052		28	28	82348	4310	D-HISTIOCYTIC LYMPHOSARCOMA,LIVER
.0043		24	24	85019	5372	E-CARCINOMA,MAMMARY GLAND
.0043		23	23	79058	3219	D-ENCEPHALITIS
.0038		20	20	81189	4303	E-THROMBOEMBOLISM
.0037		20	20	86086	5678	E-DEGENERATIVE DISC DISEASE
.0037		20	20	87006	5759	E-LYMPHOSARCOMA,SKIN
.0033		19	19	81230	3792	D-ENDOMETRITIS;CARCINOMA,LUNG
.0033		18	18	84349	5499	D-CONGESTIVE HEART FAILURE
.0030		17	17	83266	4762	D-ENTERITIS
.0030		17	17	82018	4497	E-DISC PROTRUSION
.0029		15	15	84122	4814	E-CARCINOMA,MAMMARY GLAND
.0028		15	15	82288	4250	D-HISTIOCYTIC LYMPHOSARCOMA,SPLEEN
.0027		14	14	81042	3934	D-PROSTATITIS;CARCINOMA,SALIVARY
.0023		13	13	81285	4177	D-HEPATIC DEGENERATION
.0023		13	13	82208	4628	D-PANCREATIC ISLET CELL CARCINOMA
				82084	4567	E-RENAL ATROPHY
				81005	4123	E-NECROTIZING ARTERITIS
				82174	4601	E-CARCINOMA,LUNG
				85265	5788	D-CONGESTIVE HEART FAILURE
				83223	4850	E-CARCINOMA,LUNG
				85154	5512	E-NEPHROSCLEROSIS
				83179	4680	D-CARCINOMA,LUNG
				85114	5346	E-CARCINOMA,LUNG
				86041	5470	D-THROMBOSIS,LUNG
				83067	4400	E-OSTEOSARCOMA,SACRUM;CARCINOMA,PROSTATE
				81090	3658	D-ACCIDENTAL DEATH
				84080	4743	D-NEPHRITIS,CHRONIC

ON EXPOSURE.

LY. PROMINENT FINDINGS ARE INCLUDED.

A.8 ^{91}Y in Fused Aluminosilicate Particles, Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					DOSE RATE (GY/		
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	120 DAYS
386T	04-759	F	D	70154	400	13.5	37.	520.	01	360	4900	13.	180.	9.9	4.4	
375A	01-722	M	A	70079	369	10.4	32.	330.	02	320	3300	12.	120.	8.8	3.6	1.5
384A	02-758	M	C	70153	404	12.0	28.	340.	03	300	3600	11.	130.	8.3	3.9	1.8
383S	01-760	F	B	70155	409	11.0	31.	340.	04	300	3300	11.	120.	8.3	3.6	1.5
384S	02-759	F	B	70154	405	10.9	26.	280.	05	300	3300	11.	120.	8.2	3.6	1.6
372A	03-724	M	A	70082	380	11.2	25.	280.	06	270	3100	10.	110.	7.5	3.2	1.3
384B	03-758	M	C	70153	404	10.2	24.	240.	07	260	2700	9.6	100.	7.2	3.2	1.4
392U	01-761	F	D	70156	368	9.4	17.	160.	08	260	2400	9.6	89.	7.1	3.2	1.4
385A	03-759	M	C	70154	401	11.0	13.	140.	09	230	2600	8.5	96.	6.4	2.8	1.2
393S	01-758	F	B	70153	362	10.8	14.	160.	10	210	2300	7.8	85.	5.7	2.5	1.1
374A	03-722	M	A	70079	369	10.8	11.	110.	11	200	2100	7.4	78.	5.3	2.4	1.1
387V	02-760	F	D	70155	399	7.1	15.	100.	12	190	1300	7.0	48.	5.2	2.3	1.0
489C	01-951	M	K	71257	383	7.6	13.	100.	13	190	1500	7.0	56.	5.2	2.2	0.96
484E	01-953	M	K	71259	398	9.1	11.	100.	14	180	1700	6.7	63.	5.1	2.1	0.90
423C	03-835	M	E	70342	391	8.9	8.5	74.	15	170	1500	6.3	56.	4.6	2.0	0.86
426S	04-834	F	F	70341	386	7.9	12.	96.	16	170	1300	6.3	48.	4.3	1.9	0.81
491A	04-952	M	I	71258	369	9.8	14.	140.	17	170	1700	6.3	63.	4.7	2.0	0.84
483T	04-951	F	L	71257	396	6.4	10.	63.	18	170	1100	6.3	41.	4.5	2.0	0.88
484S	03-952	F	J	71258	397	7.2	14.	96.	19	170	1200	6.3	44.	4.5	1.9	0.82
374B	01-724	M	A	70082	372	9.4	12.	110.	20	160	1500	5.9	56.	4.3	1.9	0.82
385D	01-759	M	C	70154	401	9.4	13.	120.	21	160	1500	5.9	56.	4.3	1.9	0.84
385S	04-758	F	B	70153	400	8.8	17.	150.	22	150	1300	5.5	48.	4.0	1.8	0.78
420C	01-834	M	G	70341	401	10.9	13.	140.	23	150	1700	5.5	63.	4.2	1.9	0.84
419V	04-835	F	H	70342	415	7.1	6.3	44.	24	150	1100	5.5	41.	4.2	1.8	0.79
491B	01-952	M	I	71258	369	9.0	7.4	67.	25	150	1300	5.5	48.	4.1	1.7	0.72
390V	02-761	F	D	70156	376	7.6	17.	130.	26	140	1100	5.2	41.	3.8	1.7	0.77
492A	03-956	M	I	71264	374	11.3	11.	120.	27	140	1500	5.2	56.	3.7	1.5	0.60
422C	02-834	M	E	70341	397	10.8	7.4	81.	28	130	1400	4.8	52.	3.7	1.6	0.69
485U	02-951	F	J	71257	395	6.2	8.1	52.	29	130	830	4.8	31.	3.6	1.5	0.65
489B	01-954	M	K	71260	386	10.0	8.9	89.	30	130	1300	4.8	48.	3.6	1.5	0.64
420U	01-836	F	F	70343	403	7.3	9.3	67.	31	120	880	4.4	33.	3.3	1.5	0.66
420B	01-837	M	G	70344	404	10.4	7.8	81.	32	120	1300	4.4	48.	3.3	1.5	0.64
422S	02-835	F	H	70342	398	11.3	10.	120.	33	120	1400	4.4	52.	3.3	1.4	0.58
490T	02-952	F	J	71258	370	7.9	5.2	41.	34	120	920	4.4	34.	3.2	1.4	0.62
430A	01-835	M	E	70342	372	11.6	21.	240.	35	110	1200	4.1	44.	3.0	1.3	0.60
425T	03-834	F	F	70341	387	8.2	13.	110.	36	110	940	4.1	35.	3.3	1.4	0.61
484V	04-953	F	L	71259	398	6.0	6.7	41.	37	110	680	4.1	25.	3.0	1.3	0.56
376B	02-724	M	A	70082	370	8.4	10.	85.	38	110	900	4.1	33.	3.0	1.3	0.56
422B	03-838	M	E	70348	404	11.4	5.9	67.	39	110	1200	4.1	44.	2.9	1.3	0.56
428A	02-841	M	G	70351	393	9.4	7.4	70.	40	110	1100	4.1	41.	3.1	1.3	0.57
484B	03-951	M	I	71257	396	8.6	6.3	56.	41	110	930	4.1	34.	2.9	1.2	0.52
489S	02-956	F	J	71264	390	8.1	6.7	52.	42	110	890	4.1	33.	3.0	1.3	0.52
387S	01-767	F	D	70162	406	7.7	12.	96.	43	100	800	3.7	30.	2.8	1.2	0.51
419T	02-838	F	F	70348	421	7.8	9.3	70.	44	100	800	3.7	30.	2.8	1.2	0.54
490S	03-954	F	L	71260	372	8.1	7.0	56.	45	100	850	3.7	31.	2.9	1.2	0.51
390T	04-766	F	B	70161	381	8.6	7.4	63.	46	97	830	3.6	31.	2.6	1.2	0.51
483D	02-953	M	I	71259	398	7.7	5.2	41.	47	94	720	3.5	27.	2.5	1.1	0.48
490A	02-954	M	K	71260	372	9.2	5.5	52.	48	92	840	3.4	31.	2.5	1.1	0.45
492S	04-956	F	J	71264	374	8.0	10.	85.	49	90	720	3.3	27.	2.5	0.94	0.36
428S	03-837	F	H	70344	386	7.1	7.8	56.	50	89	640	3.3	24.	2.5	1.1	0.51
484D	01-956	M	I	71264	403	7.7	6.3	48.	51	88	670	3.3	25.	2.4	1.0	0.44
488U	03-953	F	L	71259	389	8.5	4.4	41.	52	87	740	3.2	27.	2.4	1.0	0.45
420A	04-841	M	E	70351	411	12.4	7.8	96.	53	82	1000	3.0	37.	2.2	1.1	0.51
383C	01-766	M	C	70161	415	10.1	5.9	59.	54	80	820	3.0	30.	2.2	0.95	0.41
432A	04-838	M	E	70348	367	9.7	4.8	44.	55	80	780	3.0	29.	2.2	0.99	0.44

BETA RADIATION DOSE TO LUNG

DOSE RATE (GY/DAY)				CUMULATIVE (GY)							
60 DAYS	120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
4.4			2.1	410			730+	570	70267	113	D-PULMONARY INJURY
3.6	1.5		1.1	350	490		590+	510	70219	140	D-PULMONARY INJURY
3.9	1.8		0.69	350	510		650+	600	70347	194	D-PULMONARY INJURY
3.6	1.5		0.85	340	480		590+	530	70317	162	D-PULMONARY INJURY
3.6	1.6		0.51	340	480		600+	560	70356	202	D-PULMONARY INJURY
3.2	1.3		0.53	30	430		520+	490	70267	185	D-PULMONARY INJURY
3.2	1.4		0.30	300	430		530+	510	71024	236	D-PULMONARY INJURY
3.2	1.4		0.91	290	420		530+	460	70309	153	D-PULMONARY INJURY
2.8	1.2		0.59	260	380		460+	420	70327	173	D-PULMONARY INJURY
2.5	1.1		0.48	230	330		410+	370	70330	177	D-PULMONARY INJURY
2.4	1.1		0.75	220	320		400+	340	70226	147	D-PULMONARY INJURY
2.3	1.0		0.96	210	300		380+	310	70278	123	D-PULMONARY INJURY
2.2	0.96		0.078	210	300		370	370	72190	298	D-PULMONARY INJURY
2.1	0.90		0.24	200	290		350+	340	72107	213	D-PULMONARY INJURY
2.0	0.86		0.49	190	270		330+	290	71137	160	D-PULMONARY INJURY
1.9	0.81		0.28	180	250		310+	290	71172	196	D-PULMONARY INJURY
2.0	0.84		0.29	190	270		330+	310	72089	196	D-PULMONARY INJURY
2.0	0.88		0.041	180	270		330	330	72238	346	D-PULMONARY INJURY
1.9	0.82		0.39	180	260		320+	290	72065	172	D-PULMONARY INJURY
1.9	0.82		0.64	180	250		310+	260	70219	137	D-PULMONARY INJURY
1.9	0.84		0.36	180	260		320+	290	70335	181	D-PULMONARY INJURY
1.8	0.78		0.097	160	240		290	290	71062	274	D-PULMONARY INJURY
1.9	0.84		0.55	170	250		310+	270	71128	152	D-PULMONARY INJURY
1.8	0.79		0.50	170	240		300+	270	71130	153	D-PULMONARY INJURY
1.7	0.72		0.30	160	230		280+	260	72074	181	E-PULMONARY INJURY
1.7	0.77		0.13	160	230		290+	280	71043	252	E-PULMONARY INJURY
1.5	0.60		0.14	140	200		240+	230	72115	216	D-PULMONARY INJURY
1.6	0.69		0.30	150	210		260+	240	71155	179	D-PULMONARY INJURY
1.5	0.65	.019		150	210	250	250	250	74276	1115	D-BRONCHIOLOALVEOLAR CARCINOMA
1.5	0.64	.019		140	200	250	250	250	75234	1435	E-HEMANGIOSARCOMA,TBLN; B.A.CARCINOMA
1.5	0.66		0.42	140	200		250+	220	71137	159	E-PULMONARY INJURY
1.5	0.64		0.30	140	200		240+	220	71153	174	D-PULMONARY INJURY
1.4	0.58		0.27	130	190		230+	210	71150	173	D-PULMONARY INJURY
1.4	0.62	.022		130	190	230	230	230	76293	1861	D-BRONCHIOLOALVEOLAR CARCINOMA
1.3	0.60		0.059	120	180		220	220	71272	295	E-PULMONARY INJURY
1.4	0.61	.020		130	190	230	230	230	74268	1388	D-ADENOCARCINOMA,BRONCHOGENIC
1.3	0.56	.015		120	180	210	210	210	75178	1380	E-COMBINED SQUAM.CELL-B.A.CARC.
1.3	0.56	.018	0.00004	120	170	210	210	210	72162	810	D-PULMONARY INJURY
1.3	0.56	.020		120	170	210	210	210	73263	1011	D-PULMONARY INJURY
1.3	0.57	.018	0.00016	130	180	220	220	220	72325	704	D-PULMONARY INJURY
1.2	0.52	.015		120	170	200	200	200	75138	1342	D-BRONCHIOLOALVEOLAR CARCINOMA
1.3	0.52	.015		120	170	200	210	210	76321	1883	E-BRONCHIOLOALVEOLAR CARCINOMA
1.2	0.51	.016		110	160	200	200	200	77119	2514	D-BRONCHIOLOALVEOLAR CARCINOMA
1.2	0.54		0.35	110	170		200+	180	71135	152	D-PULMONARY INJURY
1.2	0.51		0.15	110	160		200+	190	72101	206	D-PULMONARY VASCULAR INJURY
1.2	0.51	.018		110	160	190	190	190	76307	2337	E-BRONCHIOLOALVEOLAR CARCINOMA
1.1	0.48	.016		100	150	180	180	180	79319	2982	E-CARCINOMA,LUNG
1.1	0.45		0.43	100	140		180+	150	72019	124	D-PULMONARY VASCULAR INJURY
0.94	0.36	.0070		95	130	150	150	150	81035	3424	D-CARCINOMA,LUNG
1.1	0.51	.020		100	150	190	190	190	77163	2376	D-SQUAMOUS CELL CARCINOMA,LUNG
1.0	0.44	.014		96	140	170	170	170	80207	3230	D-CARCINOMA,LUNG
1.0	0.45	.013		97	140	170	170	170	77356	2289	D-SQUAMOUS CELL CARCINOMA, LUNG
1.1	0.51	.024	0.011	95	140	180	180	180	72047	426	D-PULMONARY INJURY
0.95	0.41	.013		90	130	160	160	160	77353	2749	E-SQUAMOUS CELL CARC. AND OSTEOSARC.,LUNG
0.99	0.44	.017		90	130	160	160	160	80198	3502	E-CARCINOMA,LUNG

A.8 ^{91}Y in Fused Aluminosilicate Particles, Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					BETA DOSE RATE (GY/DAY)			
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	120 DAYS	365 DAYS
426A	01-838	M	G	70348	393	11.5	5.9	70.	56	79	910	2.9	34.	2.2	0.96	0.42	.015
485W	04-954	F	J	71260	398	6.6	4.8	32.	57	76	500	2.8	19.	2.1	0.98	0.46	.021
422T	03-841	F	F	70351	407	9.9	8.5	85.	58	75	740	2.8	27.	2.0	0.93	0.42	.017
425S	04-837	F	H	70344	390	10.5	10.	100.	59	73	760	2.7	28.	2.0	0.88	0.39	.014
491S	02-958	F	J	71265	376	8.1	4.1	33.	60	69	560	2.6	21.	1.9	0.75	0.30	.0075
426T	02-837	F	F	70344	389	7.4	7.4	56.	61	67	490	2.5	18.	1.8	0.79	0.34	.012
487B	01-958	M	K	71265	396	7.2	5.2	37.	62	59	430	2.2	16.	1.6	0.72	0.32	.012
391T	02-766	F	D	70161	375	8.4	7.0	59.	63	59	500	2.2	19.	1.6	0.70	0.31	.010
382B	03-766	M	C	70161	417	6.8	4.4	31.	64	57	390	2.1	14.	1.6	0.69	0.30	.011
431A	01-839	M	E	70349	376	10.1	3.7	37.	65	49	500	1.8	19.	1.3	0.59	0.26	.0089
492C	03-958	M	I	71265	375	7.2	3.4	24.	66	47	340	1.7	13.	1.3	0.54	0.23	
421T	02-836	F	F	70343	402	9.6	4.4	41.	67	45	430	1.7	16.	1.2	0.54	0.24	.0091
489T	04-958	F	L	71265	391	7.7	3.6	28.	68	44	340	1.6	13.	1.2	0.50	0.21	.0060
396X	03-767	F	B	70162	363	7.9	7.4	59.	69	44	340	1.6	13.	1.2	0.57	0.27	.012
430C	04-836	M	G	70343	373	7.9	3.3	26.	70	42	340	1.6	13.	1.1	0.48	0.20	.0058
428T	02-840	F	H	70350	392	5.7	4.1	23.	71	41	230	1.5	8.5	1.1	0.49	0.22	.0076
488B	04-959	M	I	71266	396	8.1	2.1	17.	72	39	310	1.4	11.	1.0	0.47	0.21	.0078
372B	02-722	M	A	70079	377	11.6	10.	110.	73	35	400	1.3	15.	0.93	0.38	0.15	.0037
387U	02-767	F	B	70162	406	7.8	3.4	27.	74	34	260	1.3	9.6	0.91	0.39	0.17	.0059
396S	04-767	F	D	70162	363	8.8	2.9	26.	75	33	300	1.2	11.	0.93	0.42	0.19	.0075
489D	02-959	M	K	71266	392	9.6	2.4	23.	76	33	320	1.2	12.	0.91	0.37	0.15	.0041
424S	03-839	F	H	70349	398	9.3	1.4	13.	77	31	290	1.1	11.	0.85	0.37	0.16	.0058
488S	01-960	F	J	71267	397	7.3	2.8	21.	78	31	230	1.1	8.5	0.85	0.37	0.16	.0050
386A	03-763	M	C	70159	405	11.0	1.4	16.	79	30	330	1.1	12.	0.83	0.37	0.17	.0063
376A	03-725	M	A	70084	372	8.4	1.5	13.	80	29	240	1.1	8.9	0.80	0.34	0.15	.0055
420D	03-836	M	E	70343	403	9.3	4.1	37.	81	27	250	1.0	9.3	0.72	0.32	0.15	.0055
429S	04-839	F	F	70349	382	10.2	3.2	33.	82	27	270	1.0	10.	0.72	0.32	0.14	.0048
484T	03-960	F	L	71267	406	6.3	2.5	16.	83	27	180	1.0	6.7	0.73	0.30	0.12	.0030
383V	04-763	F	D	70159	413	7.3	1.9	14.	84	23	170	0.85	6.3	0.64	0.27	0.11	.0036
422A	02-839	M	G	70349	405	11.6	1.4	16.	85	19	230	0.70	8.5	0.53	0.23	0.096	.0029
425A	01-840	M	G	70350	396	9.1	2.1	19.	86	19	180	0.70	6.7	0.52	0.23	0.10	.0039
487S	04-960	F	J	71267	398	6.6	1.7	11.	87	19	130	0.70	4.8	0.52	0.23	0.099	.0042
420S	04-840	F	H	70350	410	7.6	1.6	12.	88	18	140	0.67	5.2	0.50	0.23	0.11	.0045
382C	02-763	M	C	70159	415	7.4	1.0	7.4	89	18	130	0.67	4.8	0.49	0.21	0.091	.0037
487A	03-959	M	I	71266	397	8.1	1.1	8.9	90	16	130	0.59	4.8	0.42	0.19	0.083	.0030
492B	02-960	M	K	71267	377	8.9	1.1	10.	91	16	140	0.59	5.2	0.43	0.18	0.078	.0023
485T	01-959	F	L	71266	404	7.4	1.0	7.4	92	16	120	0.59	4.4	0.41	0.19	0.086	.0035
373A	02-725	M	A	70084	378	9.0	1.4	12.	93	15	140	0.55	5.2	0.42	0.18	0.074	.0027
383W	01-763	F	B	70159	413	7.8	1.6	13.	94	14	110	0.52	4.1	0.39	0.16	0.066	.0028
423U	03-840	F	F	70350	399	8.3	1.3	8.1	95	13	110	0.48	4.1	0.35	0.15	0.066	.0022
432B	01-841	M	E	70351	370	8.1	0.93	7.8	96	11	92	0.41	3.4	0.31	0.14	0.065	.0026
370A	01-725	M	A	70084	393	9.6			C								
381B	03-755	M	C	70147	414	11.2			C								
385T	01-755	F	B	70147	394	8.1			C								
389W	02-755	F	D	70147	381	8.4			C								
420T	01-833	F	H	70338	398	8.7			C								
424A	02-833	M	E	70338	387	9.8			C								
428U	04-833	F	F	70338	380	6.3			C								
431B	03-833	M	G	70338	365	9.2			C								
483A	02-950	M	K	71256	395	9.1			C								
485S	03-950	F	J	71256	394	8.3			C								
488C	04-950	M	I	71256	386	8.2			C								
488T	01-950	F	L	71256	386	8.6			C								

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLU

BETA RADIATION DOSE TO LUNG

RATE (GY/DAY)			CUMULATIVE (GY)							
120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
0.42	.015		89	130	160	160	160	75135	1613	D-COMBINED SQUAMOUS CELL-B-A-CARCINOMA
0.46	.021		88	130	160	170	170	79228	2890	D-PULMONARY INJURY
0.42	.017		85	120	150	160	160	78212	2783	D-B-A-CARCINOMA AND OSTEOSARCOMA,LUNG
0.39	.014		81	120	140	150	150	78263	2841	E-SQUAMOUS CELL-B-A-CARCINOMA,LUNG
0.30	.0075		74	100	120	120	120	80358	3380	E-CARCINOMA,LUNG
0.34	.012		74	110	130	130	130	80340	3648	E-CARCINOMA,MAMMARY;CARCINOMA,LUNG
0.32	.012		67	97	120	120	120	84206	4689	E-BRONCHIOLOALVEOLAR CARCINOMA,LUNG
0.31	.010		65	94	120	120	120	81169	4026	E-CARCINOMA,ADRENAL CORTEX
0.30	.011		64	92	110	110	110	80155	3646	D-CARCINOMA,LUNG
0.26	.0089		55	79	97	97	97	76005	1847	E-HEMANGIOSARCOMA,SPLEEN
0.23		0.093	52	74		90+	83	72083	183	D-PULMONARY VASCULAR INJURY
0.24	.0091		50	72	90	91	91	84019	4789	E-FIBROMAS,VAGINA
0.21	.0060		47	67	81	82	82	86055	5269	E-VERTEBRAL FRACTURE
0.27	.012		51	75	95	96	96	79021	3146	E-HEMANGIOSARCOMA,HEART
0.20	.0058		46	65	78	79	79	82337	4377	D-CARCINOMA,COLON
0.22	.0076		45	65	81	81	81	84284	5047	E-ADENOCARCINOMA,MAMMARY GLAND
0.21	.0078		43	62	77	78	78	86359	5572	D-CARCINOMA,LUNG
0.15	.0037		37	52	61	62	62	80270	3843	D-GRANULOMATOUS INFECTION
0.17	.0059		37	53	64	64	64	81182	4038	E-CARCINOMA,MAMMARY GLAND
0.19	.0075		38	56	70	70	70	83165	4751	D-CARCINOMA,LUNG
0.15	.0041		36	51	61	61	61	84344	4826	D-CONGESTIVE FAILURE,HEART
0.16	.0058		35	50	62	62	62	82307	4341	E-CARCINOMA,LUNG
0.16	.0050		34	49	60	60	60	86294	5506	D-SEPTICEMIA
0.17	.0063		34	49	61	62	62	83124	4713	E-CARCINOMA,LUNG
0.15	.0055		32	46	56	56	56	79187	3390	E-TUMOR, NASAL CAVITY
0.15	.0055		30	43	54	54	54	86220	5721	E-HEART FAILURE
0.14	.0048		30	42	52	53	53	84047	4811	E-BRONCHIOLOALVEOLAR CARCINOMA,LUNG
0.12	.0030		29	40	48	48	48	83105	4221	D-CARCINOMA,LUNG
0.11	.0036		26	36	44	44	44	83221	4810	E-ADENOCARCINOMA,MAMMARY
0.096	.0029		21	31	37	37	37	86129	5624	E-CARCINOMA,LUNG
0.10	.0039		21	31	39	39	39	79125	3062	E-TUMOR, PITUITARY
0.099	.0042		21	30	38	38	38	83270	4386	E-CARCINOMA,LUNG
0.11	.0045		21	31	39	39	39	82177	4210	D-CARCINOMA,BLADDER
0.091	.0037		20	28	35	35	35	84182	5136	E-ADENOCARCINOMA,LUNG
0.083	.0030		17	25	31	31	31	83115	4232	E-CARCINOMA,LUNG
0.078	.0023		17	25	30	30	30	84117	4598	E-ADENOCARCINOMA,PERIANAL GLAND
0.086	.0035		17	25	31	31	31	85204	5052	D-ADENOCARCINOMA,MAMMARY GLAND
0.074	.0027		17	24	29	29	29	84043	5072	D-HEART FAILURE
0.066	.0028		16	22	26	26	26	84103	5057	E-PYOMETRA
0.066	.0022		14	20	25	25	25	84138	4901	E-NEPHRITIS,CHRONIC
0.065	.0026		13	19	24	24	24	83040	4437	E-CHOLANGIO HEPATITIS
								82091	4390	E-ACCIDENTAL DEATH
								86245	5942	E-ADENOMA,PITUITARY
								83178	4779	E-ADENOCARCINOMA,MAMMARY
								82171	4407	D-PYOMETRA
								85165	5306	E-INTERSTITIAL NEPHRITIS
								85079	5220	E-PROLAPSED DISC
								85017	5158	E-MALIGNANT MELANOMA,MOUTH
								79080	3029	D-UNDETERMINED
								85312	5170	E-NEPHROSCLEROSIS
								82001	3763	D-LYMPHADENOPATHY
								86144	5367	D-RENAL CALCULI
								80332	3363	D-CARCINOMA,BLADDER

INGS ARE INCLUDED.

A.9 ^{144}Ce in Fused Aluminosilicate Particles, Longevity Study (Series I)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					BETA RAD DOSE RATE (GY/DAY)				
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	120 DAYS	365 DAYS	DI
228B	02-490	M	C	68029	372	8.4	20.	170.	01	210	1700	7.8	63.	13.	8.8	7.2		7.
210B	01-474	M	A	67348	419	7.9	16.	130.	02	190	1500	7.0	56.	11.	8.6	6.7		5.
209B	02-474	M	A	67348	421	9.1	11.	100.	03	190	1700	7.0	63.	10.	7.7	6.1		4.
208B	01-478	F	B	67355	432	11.0	17.	190.	04	180	2000	6.7	74.	10.	8.4	6.7		5.
211G	02-478	F	B	67355	424	7.5	10.	74.	05	120	890	4.4	33.	6.9	5.3	4.2		3.
226C	01-490	M	C	68029	374	7.8	11.	89.	06	96	740	3.6	27.	5.5	4.2	3.2		2.
217A	01-491	M	C	68030	407	8.8	4.8	41.	07	68	600	2.5	22.	3.8	2.9	2.2		1.
211A	03-473	M	A	67347	416	8.1	3.7	30.	08	66	540	2.4	20.	3.8	2.9	2.3		1.
211E	03-477	F	B	67354	423	8.6	4.4	41.	09	51	440	1.9	16.	2.9	2.2	1.7	.66	0.
228A	02-491	M	C	68030	373	9.9	2.5	25.	10	34	330	1.3	12.	1.9	1.4	1.1	.42	0.
211D	02-473	M	A	67347	416	7.1	2.0	14.	11	27	190	1.0	7.0	1.5	1.0	0.74	.24	0.
211F	02-477	F	B	67354	423	8.7	1.4	12.	12	19	170	0.70	6.3	1.1	0.79	0.60	.23	
223A	03-491	M	C	68030	382	9.8	1.3	12.	13	15	150	0.55	5.5	0.89	0.60	0.44	.16	
208D	01-477	F	B	67354	431	5.9	0.96	5.5	14	15	91	0.55	3.4	0.89	0.68	0.53	.20	
209C	01-473	M	A	67347	420	9.0	1.0	8.9	15	11	100	0.41	3.7	0.64	0.49	0.38	.15	
208A	01-476	M	A	67353	430	8.9			C									
209D	02-476	F	B	67353	426	7.9			C									
220C	01-492	M	C	68032	391	10.2			C									

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLUD

BETA RADIATION DOSE TO LUNG

DOSE RATE (GY/DAY)				CUMULATIVE DOSE (GY)							
60 DAYS	120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
8.8	7.2		7.0	640	1100		6700+	1300	68172	143	D-PULMONARY INJURY
8.6	6.7		5.3	580	1000		2700+	1400	68156	173	D-PULMONARY INJURY
7.7	6.1		4.7	530	940		2400+	1300	68164	181	D-PULMONARY INJURY
8.4	6.7		5.5	560	1000		2900+	1400	68172	182	D-PULMONARY INJURY
5.3	4.2		3.4	370	650		1700+	840	68161	171	D-PULMONARY INJURY
4.2	3.2		2.4	290	510		1200+	700	68218	189	E-PULMONARY INJURY
2.9	2.2		1.7	200	360		830+	480	68216	186	D-PULMONARY INJURY
2.9	2.3		1.2	200	360		880+	580	68239	257	D-PULMONARY INJURY
2.2	1.7	.66	0.37	150	270	530	720+	560	69033	410	D-PULMONARY INJURY
1.4	1.1	.42	0.015	98	170	340	460	460	71252	1318	E-HEMANGIOSARCOMA,LUNG
1.0	0.74	.24	0.012	76	130	230	300+	290	71071	1185	D-HEMANGIOSARCOMA,LUNG
0.79	0.60	.23		56	97	190	250	250	76317	3250	E-OSTEOSARCOMA,LUNG
0.60	0.44	.16		44	75	140	190	190	74309	2471	E-HEMANGIOSARCOMA,BONE
0.68	0.53	.20		47	83	170	220	220	74193	2396	D-HEMANGIOSARCOMA,TBLN.
0.49	0.38	.15		34	60	120	160	160	79143	4179	E-LYMPHOMA,VISCERAL
									82328	5454	D-RENAL ATROPHY
									80183	4578	D-RENAL AMYLOIDOSIS
									81042	4759	E-SQUAMOUS CELL CARCINOMA,TONSIL

FINDINGS ARE INCLUDED.

A.10 ^{144}Ce in Fused Aluminosilicate Particles, Longevity Study (Series II)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					DOSE	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAY
315V	02-595	F	D	69149	398	7.2	6.3	44.	01	66.	470.	2.4	17.	3.7	2.7
298B	02-586	M	A	69121	399	9.1	4.8	44.	02	65.	590.	2.4	22.	3.7	2.9
327A	01-642	M	E	69213	387	9.4	4.4	41.	03	56.	520.	2.1	19.	3.2	2.4
479U	04-947	F	L	71225	379	6.8	6.7	44.	04	54.	360.	2.0	13.	3.2	1.9
330S	02-642	F	F	69213	374	8.3	4.1	34.	05	53.	440.	2.0	16.	3.0	2.3
297S	03-586	F	B	69121	402	10.4	6.3	67.	06	46.	470.	1.7	17.	2.7	2.0
470A	03-947	M	K	71225	397	11.0	2.5	27.	07	44.	480.	1.6	18.	2.7	2.0
465S	03-918	F	J	71176	382	7.9	3.7	30.	08	41.	330.	1.5	12.	2.4	1.8
465A	04-918	M	I	71176	382	11.4	2.3	26.	09	41.	460.	1.5	17.	2.3	1.8
330U	03-641	F	F	69212	373	6.0	3.1	19.	10	37.	220.	1.4	8.1	2.2	1.5
315A	01-595	M	C	69149	398	10.9	4.8	15.	11	35.	380.	1.3	14.	2.0	1.3
330B	04-641	M	E	69212	373	6.3	2.7	17.	12	34.	220.	1.3	8.1	2.0	1.4
303A	01-586	M	A	69121	391	9.5	2.8	27.	13	33.	320.	1.2	12.	1.9	1.4
454A	03-883	M	G	71106	402	8.8	2.5	22.	14	32.	280.	1.2	10.	1.9	1.4
453S	04-883	F	H	71106	408	8.0	1.4	11.	15	29.	230.	1.1	8.5	1.7	1.3
464B	01-918	M	I	71176	385	9.4	1.7	16.	16	27.	250.	1.0	9.3	1.6	1.1
310T	02-594	F	D	69148	402	8.9	4.8	41.	17	26.	230.	0.96	8.5	1.5	1.1
460S	02-918	F	J	71176	419	7.9	3.0	23.	18	24.	190.	0.89	7.0	1.5	0.97
480S	02-947	F	L	71225	373	8.3	1.9	16.	19	24.	200.	0.89	7.4	1.5	1.0
312B	03-594	M	C	69148	399	9.0	1.8	16.	20	24.	210.	0.89	7.8	1.4	1.0
298S	03-585	F	B	69120	398	10.4	2.3	24.	21	23.	240.	0.85	8.9	1.3	0.97
455B	01-883	M	G	71106	402	11.7	2.2	26.	22	19.	220.	0.70	8.1	1.1	0.83
471A	01-947	M	K	71225	397	7.5	1.3	9.6	23	19.	150.	0.70	5.5	1.2	0.80
453T	02-883	F	H	71106	408	6.4	1.7	11.	24	18.	110.	0.67	4.1	1.0	0.75
315U	01-594	F	D	69148	397	8.3	1.9	16.	25	18.	150.	0.67	5.5	1.0	0.77
304S	01-585	F	B	69120	386	7.4	1.3	9.6	26	17.	120.	0.63	4.4	0.98	0.72
311B	03-593	M	C	69147	400	9.3	0.74	7.0	27	14.	130.	0.52	4.8	0.79	0.57
328T	02-641	F	F	69212	385	10.6	0.96	10.	28	13.	140.	0.48	5.2	0.76	0.55
467A	03-916	M	I	71175	373	12.2	0.96	11.	29	13.	160.	0.48	5.9	0.77	0.55
467T	04-946	F	L	71224	422	6.4	0.67	4.4	30	13.	81.	0.48	3.0	0.78	0.55
297B	02-585	M	A	69120	401	9.6	1.9	18.	31	12.	110.	0.44	4.1	0.68	0.45
326C	01-641	M	E	69212	391	9.4	0.67	6.3	32	12.	110.	0.44	4.1	0.70	0.51
463A	02-916	M	I	71175	411	10.9	0.74	8.1	33	12.	130.	0.44	4.8	0.74	0.50
480B	03-946	M	K	71224	372	8.2	0.74	6.3	34	11.	91.	0.41	3.4	0.68	0.46
454S	04-882	F	H	71105	401	9.6	1.5	14.	35	10.	95.	0.37	3.5	0.60	0.44
454E	03-882	M	G	71105	401	8.9	0.78	7.0	36	9.8	87.	0.36	3.2	0.60	0.42
305V	02-584	F	B	69119	382	6.9	0.67	4.4	37	9.8	67.	0.36	2.5	0.57	0.37
460T	04-916	F	J	71175	418	7.4	1.1	12.	38	9.5	70.	0.35	2.6	0.56	0.42
327B	01-640	M	E	69211	385	9.0	0.59	5.2	39	8.0	72.	0.30	2.7	0.46	0.32
323V	02-640	F	F	69211	408	7.8	0.44	3.4	40	7.8	60.	0.29	2.2	0.45	0.33
303B	03-584	M	A	69119	389	6.7	0.63	4.4	41	7.6	51.	0.28	1.9	0.44	0.34
310S	02-593	F	D	69147	401	9.1	0.35	3.2	42	6.3	57.	0.23	2.1	0.36	0.26
469S	02-946	F	L	71224	397	7.2	0.48	3.4	43	5.8	42.	0.21	1.6	0.35	0.26
478B	01-946	M	K	71224	379	9.6	0.37	3.7	44	5.7	54.	0.21	2.0	0.33	0.26
308B	01-593	M	C	69147	402	10.3	0.27	2.8	45	5.4	55.	0.20	2.0	0.31	0.23
454C	01-882	M	G	71105	401	9.5	0.52	4.8	46	5.4	51.	0.20	1.9	0.32	0.24
464T	01-916	F	J	71175	384	7.4	0.44	3.2	47	5.0	37.	0.19	1.4	0.29	0.21
455T	02-882	F	H	71105	401	10.4	0.59	6.3	48	4.9	51.	0.18	1.9	0.30	0.21
313S	01-598	F	D	69160	411	7.9	0.30	2.4	49	2.4	19.	0.089	0.70	0.14	0.09
296B	01-592	M	A	69135	418	10.0	0.14	1.4	50	2.1	21.	0.078	0.78	0.12	0.08
466V	04-915	F	J	71174	380	7.9	0.17	1.3	51	2.0	15.	0.074	0.55	0.11	0.08
313C	02-598	M	C	69160	411	9.6	0.14	1.4	52	1.8	17.	0.067	0.63	0.10	0.07
304T	02-592	F	B	69135	401	7.8	0.093	0.70	53	1.6	12.	0.059	0.44	0.092	0.06
324V	03-638	F	F	69210	402	7.2	0.14	1.0	54	1.5	11.	0.056	0.41	0.083	0.06
331A	04-638	M	E	69210	370	9.0	0.081	0.74	55	1.3	11.	0.048	0.41	0.073	0.05

BETA RADIATION DOSE TO LUNG

L	DOSE RATE (GY/DAY) 60 DAYS	365 DAYS	AT DEATH	CUMULATIVE DOSE (GY) 60 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
	2.7		1.3	190.		890. +	530.	70030	246	D-PULMONARY INJURY
	2.9		1.5	200.		1000. +	570.	69355	234	D-PULMONARY INJURY
	2.4		0.99	170.		840. +	500.	70121	273	D-PULMONARY INJURY
	1.9	.57	0.12	140.	470.	620. +	590.	73284	790	E-HEMANGIOSARCOMA,LUNG
	2.3		0.91	150.		710. +	500.	70127	279	D-PULMONARY INJURY
	2.0	.60	0.15	140.	500.	660. +	610.	71141	750	E-HEMANGIOSARC. AND FIBROSARC.,LUNG
	2.0		0.69	140.		530. +	410.	72135	275	D-PULMONARY INJURY
	1.8		0.91	120.		460. +	280.	71361	185	D-PULMONARY INJURY
	1.8		0.66	120.		570. +	410.	72122	311	D-PULMONARY INJURY
	1.5	.43	0.032	110.	360.	470. +	460.	72194	1077	E-HEMANGIOSARCOMA,LUNG
	1.3	.43	0.060	95.	330.	460. +	430.	71335	916	D-HEMANGIOSARC. AND B-A-CARCINOMA,LUNG
	1.4	.38		100.	340.	440.	440.	75334	2313	D-HEM-SARC.,SITE UND.;B-A-CARC.,LUNG
	1.4		0.74	98.		390. +	240.	69314	193	D-PULMONARY VASCULAR INJURY
	1.4	.31	0.012	98.	310.	380.	380.	74238	1228	D-PULMONARY THROMBOSIS;AMYLOIDOSIS
	1.3	.41	0.018	89.	330.	440. +	430.	74236	1226	D-HEM-SARC.-B-A-CARC.-BRONCHO.CA.,LUNG
	1.1	.29	0.0030	80.	260.	330.	330.	75238	1523	D-BRONCHIOLOALVEOLAR CARCINOMA
	1.1	.33	0.079	77.	270.	360. +	340.	71183	765	E-HEMANGIOSARCOMA,LUNG
	0.97	.27		72.	230.	300.	300.	76160	1810	D-MIXED TUMOR,LUNG;B-A-CARCINOMA
	1.0	.29	0.0091	73.	250.	320.	320.	75017	1253	E-SQUAMOUS CELL CARCINOMA,NASAL CAVITY
	1.0	.31	0.0015	72.	250.	340.	340.	74217	1895	D-HEMANGIOSARCOMA,SPLEEN
	0.97	.29		68.	230.	320.	320.	77199	3001	E-MIXED TUMOR,LUNG; OSTEOSARCOMA,LUNG
	0.83	.23		58.	200.	260.	260.	77093	2179	D-EPILEPSY
	0.80	.22		57.	190.	250.	250.	77216	2183	E-HEMANGIOSARCOMA,BONE
	0.75	.20		53.	180.	230.	230.	78277	2728	E-HEMANGIOSARCOMA,SPLEEN
	0.77	.21		54.	180.	240.	240.	80092	3961	D-ADENOCARCINOMA,LUNG
	0.72	.21	0.00018	50.	170.	230.	230.	75256	2327	D-HEMANGIOSARCOMA,LIVER
	0.57	.16	0.00060	40.	140.	180.	180.	74295	1974	E-HEMANGIOSARCOMA,BOTH HUMERI
	0.55	.15		39.	130.	170.	170.	79365	3805	E-GASTROENTEROPATHY
	0.55	.14		39.	13.	160.	160.	76112	1763	D-HEMANGIOSARCOMA,TBLN
	0.55	.17		39.	140.	180.	180.	76147	1749	D-ACCIDENTAL DEATH
	0.45	.14		33.	110.	150.	150.	76065	2501	D-PLEURITIS (NOCARDIA SP.)
	0.51	.14		36.	120.	160.	160.	78205	3280	E-HEMANGIOSARCOMA,TBLN
	0.50	.14		36.	120.	150.	150.	79102	2849	D-HEMANGIOSARCOMA,HEART
	0.46	.14		33.	110.	150.	150.	82125	3919	E-HEMANGIOSARC.,TBLN;CARCINOMA,LUNG
	0.44	.12	0.0013	31.	100.	130.	130.	75171	1527	D-HEMANGIOSARCOMA,HEART
	0.42	.12		30.	100.	130.	130.	77278	2365	E-HEMANGIOSARCOMA,DERMIS
	0.37	.10		46.	120.	120.	120.	85021	5746	D-CARCINOMA,SKIN
	0.42	.12		29.	100.	130.	130.	80189	3301	E-CHRONIC TRACHEITIS
	0.32	.097		23.	78.	110.	110.	82316	4853	E-CARCINOMA,LUNG
	0.33	.092	0.00010	23.	79.	100.	100.	75127	2107	D-HEMANGIOSARCOMA,TBLN
	0.34	.12		23.	86.	120.	120.	76133	2570	E-HEMANGIOSARCOMA,LIVER
	0.26	.077		18.	63.	85.	85.	81049	4285	E-CARCINOMA,LUNG
	0.26	.080		18.	64.	86.	86.	83235	4394	E-INTERSTITIAL NEPHRITIS;LUNG CARC.
	0.26	.083		18.	64.	87.	87.	78169	2502	D-HEMANGIOSARCOMA,TBLN
	0.23	.00028		16.	57.	77.	77.	82342	4943	D-MYOCARDIAL DEGENERATION;LUNG TUMOR
	0.24	.067		17.	57.	78.	78.	78301	2753	E-HEMANGIOSARCOMA,DISSEMINATED
	0.21	.053		15.	48.	62.	62.	82112	3955	D-PYOMETRA AND HEMANGIOMA,TBLN
	0.21	.050		15.	47.	60.	60.	76072	1793	E-HEMANGIOSARCOMA,SITE UNDETERMINED
	0.098	.029		7.0	24.	32.	32.	79257	3749	D-HEMANGIOSARCOMA,TBLN
	0.089	.028		6.2	22.	30.	30.	81162	4410	D-CONGEST. HEART FAIL.;CARCINOMA,LUNG
	0.086	.025		5.9	21.	27.	27.	85238	5178	E-ADENOCARCINOMA,MAMMARY GLAND
	0.079	.025		5.4	19.	26.	26.	76083	2479	D-PERITONITIS (NOCARDIA SP.)
	0.068	.022		4.7	17.	23.	23.	79324	3841	E-ADENOCARCINOMA,BLADDER
	0.067	.021		4.5	17.	22.	22.	82160	4698	E-CARCINOMA,LUNG
	0.059	.019		3.9	15.	20.	20.	79132	3574	D-UNDETERMINED

A.10 ^{144}Ce in Fused Aluminosilicate Particles, Longevity Study (Series II) (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					DOSE RATE (G		
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	D
461B	03-915	M	I	71174	417	11.1	0.11	1.2	56	1.2	13.	0.044	0.48	0.071	0.052	.01
467U	04-945	F	L	71223	421	6.6	0.10	0.67	57	1.2	7.5	0.044	0.28	0.067	0.050	.01
477A	03-945	M	K	71223	380	11.0	0.067	1.1	58	1.1	12.	0.041	0.44	0.066	0.050	.01
329C	03-642	M	E	69213	386	8.3	0.044	0.37	59	0.71	5.9	0.026	0.22	0.041	0.030	.00
453B	03-881	M	G	71104	406	8.1	0.052	0.44	60	0.63	5.1	0.023	0.19	0.037	0.028	.00
463S	02-915	F	J	71174	410	10.4	0.028	0.30	61	0.53	5.5	0.020	0.20	0.037	0.023	.00
452U	04-881	F	H	71104	416	8.2	0.17	1.4	62	0.52	4.2	0.019	0.16	0.040	0.024	.00
314S	04-597	F	D	69157	407	9.7	0.030	0.29	63	0.45	4.4	0.017	0.16	0.026	0.018	.00
296U	02-591	F	B	69134	417	8.4	0.030	0.25	64	0.44	3.7	0.016	0.14	0.024	0.018	.00
313B	03-597	M	C	69157	408	10.1	0.041	0.41	65	0.37	3.7	0.014	0.14	0.021	0.015	.00
461A	01-915	M	I	71174	417	12.0	0.018	0.22	66	0.35	4.3	0.013	0.16	0.022	0.015	.00
322V	02-638	F	F	69210	409	6.4	0.026	0.16	67	0.32	2.0	0.012	0.074	0.019	0.014	.00
476C	01-945	M	K	71223	387	9.0	0.021	0.19	68	0.30	2.7	0.011	0.10	0.018	0.014	.00
471S	02-945	F	L	71223	395	6.3	0.033	0.21	69	0.25	1.6	0.0093	0.059	0.014	0.011	.00
297A	01-591	M	A	69134	415	11.0	0.014	0.16	70	0.18	2.0	0.0067	0.074	0.011	0.0080	.00
453U	02-881	F	H	71104	406	5.8	0.016	0.089	71	0.18	1.1	0.0067	0.041	0.011	0.0087	.00
457B	01-881	M	G	71104	374	8.3	0.014	0.11	72	0.17	1.4	0.0063	0.052	0.011	0.0078	.00
472W	02-942	F	L	71222	390	8.0	0.013	0.11	73	0.16	1.3	0.0059	0.048	0.0095	0.0074	.00
298U	02-590	F	B	69129	407	9.4	0.013	0.13	74	0.12	1.2	0.0044	0.044	0.0071	0.0056	.00
462C	02-914	M	I	71173	409	9.0	0.0059	0.052	75	0.083	0.75	0.0031	0.028	0.0049	0.0038	.00
476B	01-942	M	K	71222	386	8.5	0.0041	0.036	76	0.079	0.67	0.0029	0.025	0.0047	0.0037	.00
303S	02-589	F	B	69128	398	8.9	0.0085	0.078	77	0.077	0.68	0.0028	0.025	0.0046	0.0036	.00
308U	01-597	F	D	69157	412	10.1	0.0048	0.048	78	0.076	0.77	0.0028	0.028	0.0045	0.0035	.00
464S	01-914	F	J	71173	382	8.1	0.0044	0.037	79	0.062	0.50	0.0023	0.019	0.0037	0.0029	.00
451T	04-880	F	H	71103	415	8.0	0.0033	0.026	80	0.057	0.45	0.0021	0.017	0.0034	0.0026	.00
310A	02-597	M	C	69157	411	11.5	0.0078	0.089	81	0.051	0.59	0.0019	0.022	0.0030	0.0024	.00
304A	01-590	M	A	69129	395	11.3	0.0056	0.063	82	0.044	0.50	0.0016	0.019	0.0026	0.0020	.00
310U	03-596	F	D	69156	410	8.0	0.011	0.089	83	0.041	0.33	0.0015	0.012	0.0024	0.0019	.00
323T	05-636	F	F	69209	406	8.4	0.0056	0.044	84	0.039	0.33	0.0014	0.012	0.0023	0.0018	.00
306A	01-589	M	A	69128	389	9.5	0.0070	0.063	85	0.033	0.31	0.0012	0.011	0.0020	0.0015	.00
312A	04-596	M	C	69156	407	11.0	0.0018	0.020	86	0.025	0.27	0.00092	0.010	0.0015	0.0012	.00
472U	02-941	F	L	71221	389	8.5	0.0013	0.011	87	0.020	0.17	0.00074	0.0063	0.0012	0.00093	.00
465B	01-912	M	I	71172	378	11.2	0.0015	0.017	88	0.018	0.20	0.00067	0.0074	0.0011	0.00083	.00
450D	03-880	M	G	71103	419	11.1	0.0025	0.027	89	0.018	0.20	0.00067	0.0074	0.0011	0.00083	.00
327D	06-636	M	E	69209	383	8.7	0.0029	0.025	90	0.016	0.14	0.00059	0.0052	0.00095	0.00074	.00
462S	02-912	F	J	71172	408	8.1	0.0015	0.012	91	0.014	0.11	0.00052	0.0041	0.00083	0.00065	.00
327C	03-636	M	E	69209	383	9.4	0.0023	0.021	92	0.0096	0.090	0.00036	0.0033	0.00057	0.00044	.00
478C	01-941	M	K	71221	376	8.9	0.00092	0.0081	93	0.0092	0.081	0.00034	0.0030	0.00054	0.00043	.00
324T	04-636	F	F	69209	401	10.8	0.0020	0.021	94	0.0063	0.068	0.00023	0.0025	0.00037	0.00029	.00
453A	01-880	M	G	71103	405	9.0	0.00019	0.0017	95	0.0030	0.027	0.00011	0.0010	0.00018	0.00014	.00
452T	02-880	F	H	71103	415	9.4	0.00007	0.0067	96	0.0024	0.023	0.000089	0.00085	0.00014	0.00011	.00
303V	01-588	F	B	69127	397	7.5			C							
306D	02-588	M	A	69127	388	9.4			C							
308T	02-596	F	D	69156	411	9.3			C							
310B	01-596	M	C	69156	410	11.0			C							
322U	02-636	F	F	69209	408	6.8			C							
324B	01-636	M	E	69209	401	8.8			C							
450A	01-878	M	G	71099	415	11.8			C							
452S	02-878	F	H	71099	411	10.2			C							
464U	02-911	F	J	71169	378	8.9			C							
467B	01-911	M	I	71169	367	6.9			C							
477B	01-940	M	K	71218	375	8.7			C							
479T	02-940	F	L	71218	372	8.0			C							

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDED.

BETA RADIATION DOSE TO LUNG

DOSE RATE (GY/DAY)			CUMULATIVE DOSE (GY)						
60 DAYS	365 DAYS	AT DEATH	60 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
).052	.016		3.6	13.	17.	17.	80291	3404	E-LYMPHOSARCOMA,DISSEMINATED
).050	.014		3.5	12.	16.	16.	86261	5517	E-PYELONEPHRITIS
).050	.013		3.4	12.	15.	15.	87114	5735	E-NEPHRITIS,KIDNEY
).030	.0096		2.1	7.5	10.	10.	81096	4266	E-HEMANGIOSARCOMA,SPLEEN
).028	.0084		1.9	6.8	9.1	9.1	82285	4199	E-CARCINOMA,THYROID
).023	.0068		1.6	5.6	7.4	7.4	86095	5400	D-CARCINOMA,MAMMARY
).024	.0072		1.7	5.9	7.7	7.7	84201	4845	E-ADENOCARCINOMA,MAMMARY GLAND
).018	.0051		1.3	4.3	5.7	5.7	84226	5547	E-ADENOCARCINOMA,MAMMARY GLAND
).018	.0049		1.2	4.2	5.5	5.5	76260	2682	D-TRANSITIONAL CELL CARCINOMA,BLADDER
).015	.0042		1.1	3.6	4.7	4.7	81127	4353	E-CAR.,KID.;LYMPHOSAR,SPLEEN;CAR.,LUNG
).015	.0048		1.1	3.8	5.0	5.0	81215	3694	E-PERINEAL HERNIA
).014	.0044		0.96	3.4	4.7	4.7	83210	5113	D-HEMANGIOSARCOMA,SPLEEN
).014	.0047		0.94	3.5	4.8	4.8	86030	5286	D-BRONCHIOLITIS
).011	.0034		0.74	2.7	3.6	3.6	84154	4679	D-SPONDYLITIS,ACUTE
).0080	.0023		0.57	1.9	2.5	2.5	82071	4685	E-NECROTIZING PNEUMONIA
).0087	.0030		0.58	2.2	3.1	3.1	83113	4392	E-CARCINOMA,MAMMARY GLAND
).0078	.0026		0.52	2.0	2.7	2.7	83187	4466	E-PITUITARY TUMOR
).0074	.0021		0.50	1.8	2.3	2.3	88150	6137	D-MUSCLE ABSCESSATION
).0056	.0016		0.38	1.3	1.7	1.7	81083	4337	E-NECROTIZING HEPATITIS;CARC.,LUNG
).0038	.0011		0.26	0.93	1.2	1.2	82096	3941	E-ADENOCARCINOMA,PROSTATE
).0037	.0011		0.25	0.88	1.1	1.1	85110	5002	D-ENTERITIS
).0036	.0010		0.24	0.86	1.1	1.1	79054	3578	E-PERIPHERAL NERVE TUMOR
).0035	.0010		0.24	0.85	1.1	1.1	79323	3818	E-CARCINOMA,MAMMARY GLAND
).0029	.00083		0.19	0.69	0.90	0.90	80252	3366	D-PYOMETRA
).0026	.00076		0.18	0.64	0.82	0.82	86041	5417	D-BRONCHOPNEUMONIA
).0024	.00068		0.16	0.57	0.74	0.74	84227	5548	E-NEPHRITIS,CHRONIC
).0020	.00059		0.14	0.49	0.64	0.64	85093	5808	E-INTERSTITIAL NEPHRITIS
).0019	.00055		0.13	0.46	0.59	0.59	86152	6205	D-EPILEPSY
).0018	.00052		0.12	0.44	0.56	0.56	83100	5004	D-CARCINOMA,LUNG
).0015	.00044		0.10	0.37	0.48	0.48	84054	5404	E-MENINGIOMA,BRAIN
).0012	.00033		0.079	0.28	0.36	0.36	85149	5837	E-INTERSTITIAL NEPHRITIS
).00093	.00027		0.063	0.22	0.29	0.29	78276	2612	D-ACCIDENTAL DEATH
).00083	.00024		0.057	0.20	0.26	0.26	86189	5496	E-DISC PROTRUSION
).00083	.00024		0.057	0.20	0.26	0.26	83110	4390	E-CARCINOMA,TONSIL
).00074	.00021		0.050	0.18	0.23	0.23	80279	4087	D-CONGESTIVE HEART FAILURE
).00065	.00019		0.044	0.16	0.20	0.20	83007	4218	E-PITUITARY TUMOR
).00044	.00013		0.030	0.11	0.14	0.14	83215	5119	D-HEPATIC DEGENERATION
).00043	.00012		0.029	0.10	0.13	0.13	82353	4150	D-CHRONIC ENTERITIS
).00029	.000084		0.020	0.071	0.091	0.091	84355	5624	E-CONGESTIVE HEART FAILURE
).00014	.000040		0.0094	0.034	0.043	0.043	85253	5264	E-INTERSTITIAL NEPHRITIS
).00011	.000032		0.0075	0.027	0.035	0.035	86154	5530	D-PULMONARY FIBROSIS
							80261	4151	D-HEMOLYTIC ANEMIA
							83247	5233	D-CHRONIC PANCREATITIS
							80323	4184	D-MAST CELL TUMOR,SPLEEN
							82025	4617	D-HYPERADRENOCORTICISM
							83299	5203	D-TRANSITIONAL CELL CARC.,BLADDER
							84100	5369	E-NEPHRITIS,CHRONIC
							85042	5057	E-ANKYLOSING SPONDYLITIS
							82276	4195	D-ADENOCARCINOMA,STOMACH
							83180	4394	E-CARCINOMA,LUNG
							83082	4296	E-LYMPHOSARCOMA,GENERALIZED
							86020	5281	E-HEART,CHRONIC INFARCTION
							84122	4652	E-ASTROCYTOMA,BRAIN

CLUDED.

A.11 ^{144}Ce in Fused Aluminosilicate Particles, Sacrifice Study (Series II, III, IV)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					BETA RAD DOSE RATE (GY/DAY)				
TATTOO	AN-EXPT	SEX	SER	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	120 DAYS	365 DAYS	D
541S	01-999	F	II	72103	395	7.9	5.2	41.	01	71	560	2.6	21.	4.1	3.1	2.3		2.
520A	02-998	M	II	72102	427	11.0	4.8	52.	02	66	720	2.4	27.	3.7	2.8	2.1		1.
530C	04-1007	M	II	72115	417	9.2	5.2	48.	03	64	590	2.4	22.	3.7	2.6	2.1		1.
530B	01-1002	M	II	72109	411	9.5	3.4	32.	04	60	560	2.2	21.	3.4	2.2			1.
525W	01-1004	F	II	72111	428	7.3	4.1	30.	05	58	420	2.1	16.	3.4	2.5	1.9		1.
527A	03-1007	M	II	72115	418	9.2	2.9	27.	06	54	500	2.0	19.	3.1	2.1	1.6		0.
521T	03-998	F	II	72102	426	8.7	3.4	30.	07	52	450	1.9	17.	3.1	2.4	1.8		1.
526A	01-1001	M	II	72108	416	7.5	3.6	27.	08	52	390	1.9	14.	3.0	2.0			1.
526B	02-1000	M	II	72104	412	5.8	4.4	25.	09	52	300	1.9	11.	3.1	2.2	1.6		1.
526S	01-1007	F	II	72115	423	6.6	3.7	25.	10	51	330	1.9	12.	2.9	2.1			1.
525T	02-1003	F	II	72110	427	8.8	4.1	37.	11	48	420	1.8	16.	2.9	2.1	1.6		1.
522T	03-1003	F	II	72110	432	8.0	5.2	41.	12	48	380	1.8	14.	2.9	2.1	1.6		0.
525U	02-1004	F	II	72111	428	9.1	3.3	30.	13	46	420	1.7	16.	2.8	1.9	1.4	.53	0.
539A	03-997	M	II	72101	394	9.3	4.4	41.	14	41	380	1.5	14.	2.4	1.8	1.3	.48	0.
530A	04-998	M	II	72102	404	11.5	3.1	35.	15	39	450	1.4	17.	2.3	1.8	1.3		0.
541U	01-1000	F	II	72104	396	7.9	2.3	18.	16	35	280	1.3	10.	2.1	1.4	1.1	.40	0.
535C	03-1000	M	II	72104	399	7.7	2.6	20.	17	34	260	1.3	9.6	2.0	1.4	1.1	.44	0.
539D	04-1000	M	II	72104	397	7.9	1.9	15.	18	33	260	1.2	9.6	1.9	1.4	1.0	.39	0.
522U	01-998	F	II	72102	424	7.8	3.4	27.	19	33	250	1.2	9.3	1.9	1.4	0.99		0.
526C	02-997	M	II	72101	409	6.9	2.5	17.	20	33	230	1.2	8.5	1.9	1.3	0.96	.35	0.
519S	04-1004	F	II	72111	439	8.3	2.7	23.	21	32	270	1.2	10.	1.9	1.4	1.0	.38	0.
524S	02-1001	F	II	72108	425	6.7	2.0	14.	22	32	210	1.2	7.8	1.9	1.3	1.0	.42	0.
522S	04-997	F	II	72101	423	8.7	2.9	25.	23	31	270	1.1	10.	1.8	1.4	1.1		0.
527B	02-1002	M	II	72109	412	9.3	2.1	19.	24	31	290	1.1	11.	1.8	1.3	0.95	.33	0.
532U	02-1007	F	II	72115	413	7.8	1.6	12.	25	31	240	1.1	8.9	1.8	1.3	0.98	.36	
521B	03-999	M	II	72103	427	7.6	3.1	24.	26	30	230	1.1	8.5	1.7	1.3	1.0	.39	0.
536T	03-1001	F	II	72108	403	7.6	2.4	19.	27	29	220	1.1	8.1	1.7	1.2	0.88		0.
519T	03-1004	F	II	72111	439	8.7	3.4	29.	28	28	240	1.0	8.9	1.7	1.2			0.
527D	01-997	M	II	72101	404	7.9	1.7	14.	29	27	220	1.0	8.1	1.6	1.2	0.90	.36	0.
519A	03-1002	M	II	72109	437	8.6	4.1	35.	30	27	230	1.0	8.5	1.6	1.2	0.87	.33	0.
520B	04-1003	M	II	72110	435	11.9	6.7	78.	31	26	310	0.96	11.	1.6	1.2	0.85	.29	0.
523T	02-1008	F	II	72116	435	6.0	1.7	10.	32	26	150	0.96	5.5	1.5	0.99	0.73	.29	0.
543C	04-1004	M	II	72109	399	7.6	1.6	12.	33	26	190	0.96	7.0	1.5	1.1	0.84	.34	
520S	01-1003	F	II	72110	435	6.7	2.5	17.	34	24	160	0.89	5.9	1.5	1.1	0.82	.31	0.
526D	02-999	M	II	72103	411	5.5	1.9	10.	35	16	86	0.59	3.2	0.94	0.68	0.51	.20	0.
541A	05-1000	M	II	72104	396	8.3	1.0	8.5	36	16	140	0.59	5.2	0.92	0.67	0.51	.19	0.
538S	04-1001	F	II	72108	402	6.7	0.89	5.9	37	14	95	0.52	3.5	0.83	0.57	0.42	.16	
533T	01-1008	F	II	72116	413	5.9	0.74	4.4	38	14	81	0.52	3.0	0.79	0.56	0.41	.16	
523S	01-995	F	II	72097	416	8.8			C									
533A	03-995	M	II	72097	394	8.3			C									
538B	02-995	M	II	72097	391	9.3			C									
540T	05-995	F	II	72097	389	5.7			C									
542A	06-995	M	II	72097	388	9.1			C									
542S	04-995	F	II	72097	388	8.2			C									
521S	06-996	F	II	72098	422	8.6			C									
522A	03-996	M	II	72098	420	8.7			C									
522V	01-996	F	II	72098	420	7.8			C									
530S	05-996	F	II	72098	400	8.6			C									
540B	04-996	M	II	72098	390	8.0			C									
547B	02-996	M	II	72098	378	10.4			C									

BETA RADIATION DOSE TO LUNG

IAL	DOSE RATE (GY/DAY) 60 DAYS	120 DAYS	365 DAYS	AT DEATH	CUMULATIVE DOSE (GY) 60 DAYS	120 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
	3.1	2.3		2.2	210	370		850+	390	72231	128	S-PULMONARY INJURY
	2.8	2.1		1.5	190	340		770+	450	72283	181	S-PULMONARY INJURY
	2.6	2.1		1.3	190	330		990+	550	73005	256	S-PULMONARY INJURY
	2.2			1.9	170			870+	210	72189	80	S-PULMONARY INJURY
	2.5	1.9		1.4	180	310		700+	400	72290	179	S-PULMONARY INJURY
	2.1	1.6		0.99	150	260		750+	420	73003	254	E-PULMONARY INJURY
	2.4	1.8		1.7	160	290		680+	300	72230	128	S-PULMONARY INJURY
	2.0			1.7	150			750+	190	72189	81	S-PULMONARY INJURY
	2.2	1.6		1.1	160	270		550+	350	72284	180	S-PULMONARY INJURY
	2.1			1.9	150			740+	190	72196	81	S-PULMONARY INJURY
	2.1	1.6		1.5	150	260		580+	280	72241	131	S-PULMONARY INJURY
	2.1	1.6		0.99	150	260		760+	430	73002	258	S-PULMONARY INJURY
	1.9	1.4	.53	0.27	140	240	450	610+	530	73316	571	E-PULMONARY INJURY
	1.8	1.3	.48	0.28	120	220	410	560+	470	73249	514	S-PULMONARY INJURY
	1.8	1.3		0.62	120	220		510+	370	73025	289	D-PULMONARY INJURY
	1.4	1.1	.40	0.026	100	180	340	450	450	75101	1093	S-PULMONARY INJURY
	1.4	1.1	.44	0.14	99	170	340	470+	430	74056	683	D-PULMONARY INJURY
	1.4	1.0	.39	0.099	96	170	330	430	410	74113	740	S-PULMONARY INJURY
	1.4	0.99		0.94	96	170		350+	170	72230	128	S-PULMONARY INJURY
	1.3	0.96	.35	0.19	94	160	310	400+	350	73250	515	S-PULMONARY INJURY
	1.4	1.0	.38	0.025	98	170	330	430	430	75106	1091	S-PULMONARY INJURY
	1.3	1.0	.42	0.059	93	160	330	450+	430	74294	917	S-PULMONARY INJURY
	1.4	1.1		0.57	95	170		400+	280	72357	256	S-PULMONARY INJURY
	1.3	0.95	.33	0.0046	92	160	300	390	390	76153	1505	D-HEMANGIOSARCOMA,LUNG
	1.3	0.98	.36		91	160	310	410	410	78145	2222	E-HEMANGIOSARCOMA,HEART
	1.3	1.0	.39	0.028	92	160	320	430	430	75106	1099	S-HEMANGIOSARCOMA,LUNG
	1.2	0.88		0.50	86	150		390+	240	73002	260	S-PULMONARY INJURY
	1.2			0.86	86			330+	160	72241	130	S-PULMONARY INJURY
	1.2	0.90	.36	0.22	84	150	290	410+	330	73257	522	D-PULMONARY INJURY
	1.2	0.87	.33	0.042	81	140	280	370+	350	74295	917	S-PULMONARY INJURY
	1.2	0.85	.29	0.054	82	140	270	360+	340	74267	888	D-PULMONARY INJURY
	0.99	0.73	.29	0.17	73	120	240	320+	270	73264	514	S-PULMONARY INJURY
	1.1	0.84	.34		78	140	270	360	360	80144	2957	E-HEMANGIOSARCOMA,LUNG
	1.1	0.82	.31	0.073	76	130	260	340+	320	74114	735	S-PULMONARY INJURY
	0.68	0.51	.20	0.052	48	83	160	220+	200	74114	742	S-PULMONARY INJURY
	0.67	0.51	.19	0.052	47	82	160	220+	200	74113	740	S-PULMONARY INJURY
	0.57	0.42	.16		41	71	140	180	180	84350	4625	D-CARCINOMA.LUNG
	0.56	0.41	.16		40	69	130	180	180	82303	3840	D-INTERSTITIAL PNEUMONIA
										72354	257	S-NORMAL
										72224	127	S-NORMAL
										86171	5188	E-ENTERITIS
										83298	4219	D-PULMONARY THROMBOSIS
										74108	742	S-NORMAL
										85316	4968	E-NEPHROSCLEROSIS
										86122	5138	E-LYMPHOSARCOMA, GENERALIZED
										79104	2563	D-MYOCARDIAL INFARCT
										75104	1102	S-NORMAL
										75014	1012	S-NORMAL
										74108	741	S-NORMAL
										85031	4682	E-ADENOCARCINOMA,PROSTATE

A.11 ^{144}Ce in Fused Aluminosilicate Particles, Sacrifice Study (Series II, III, IV) (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					BETA DOSE RATE (GY/DAY			
TATTOO	AN-EXPT	SEX	SER	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	120 DAYS	365 DAYS
538A	03-1016	M	III	72137	428	9.1	3.5	32.	01	69	630	2.6	23.	3.8	2.9	2.2	
540U	01-1013	F	III	72132	424	6.6	5.5	37.	02	59	390	2.2	14.	3.4	2.6	1.9	
535T	01-1015	F	III	72136	431	6.3	9.3	59.	03	50	320	1.9	12.	2.6	1.8	1.3	
535B	03-1019	M	III	72144	438	7.8	5.2	41.	04	50	390	1.9	14.	2.9	2.2	1.7	
540S	04-1019	F	III	72144	435	6.5	8.1	52.	05	50	320	1.9	12.	2.7	2.1	1.6	
539B	02-1014	M	III	72133	426	8.6	3.5	30.	06	48	410	1.8	15.	2.7	2.0	1.5	
542C	03-1014	M	III	72133	424	7.8	4.8	37.	07	48	380	1.8	14.	2.2	1.5	1.1	.39
547C	02-1015	M	III	72136	416	9.9	2.8	28.	08	25	340	0.93	13.	2.0	1.4	1.1	.42
535A	01-1019	M	III	72144	438	7.9	3.7	30.	09	34	270	1.3	10.	1.9	1.4	1.0	
547T	04-1014	F	III	72133	413	7.1	3.1	22.	10	32	230	1.2	8.5	1.8	1.2	0.93	.37
544T	02-1019	F	III	72144	432	7.4	3.7	28.	11	32	230	1.2	8.5	1.8	1.3	0.95	
530T	04-1016	F	III	72137	439	10.2	2.7	27.	12	29	300	1.1	11.	1.6	1.2	0.92	.38
527C	06-1017	M	III	72140	443	10.2			C								
541W	04-1017	F	III	72140	432	8.7			C								
544U	05-1017	F	III	72140	429	7.0			C								
547D	01-1017	M	III	72140	420	7.3			C								
539C	01-1018	M	III	72143	436	8.5			C								
541T	02-1018	F	III	72143	435	8.4			C								
539T	03-1013	F	IV	72132	425	8.6	4.4	37.	01	41	350	1.5	13.	2.2	1.8	1.4	.57
543A	04-1013	M	IV	72132	422	10.8	3.1	34.	02	33	250	1.2	9.3	1.9	1.4	1.1	.39
541V	02-1016	F	IV	72137	429	7.8	2.6	20.	03	33	260	1.2	9.6	1.9	1.3	1.0	.41
542B	01-1016	M	IV	72137	428	9.7	4.1	41.	04	32	320	1.2	12.	1.9	1.2	0.83	.32
543B	01-1014	M	IV	72133	423	9.2	1.6	15.	05	31	290	1.1	11.	1.8	1.3	0.94	.33
543S	02-1013	F	IV	72132	422	9.2	3.7	35.	06	29	270	1.1	10.	1.5	1.1	0.87	.34
530U	03-1017	F	IV	72140	442	8.5			C								
538C	07-1017	M	IV	72140	434	7.5			C								
539S	02-1017	F	IV	72140	433	7.6			C								

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE I

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BETA RADIATION DOSE TO LUNG											
DOSE RATE (GY/DAY)				CUMULATIVE DOSE (GY)							
L	60 DAYS	120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
	2.9	2.2		1.4	200	350		820+	520	72350	213	S-PULMONARY INJURY
	2.6	1.9		1.3	180	310		720+	430	72329	197	D-PULMONARY INJURY
	1.8	1.3		0.65	130	220		620+	410	73089	319	S-PULMONARY INJURY
	2.2	1.7		1.6	150	270		670+	310	72286	142	S-PULMONARY INJURY
	2.1	1.6		1.4	140	250		600+	290	72286	142	S-PULMONARY INJURY
	2.0	1.5		0.51	140	250		590+	460	73124	357	S-PULMONARY INJURY
	1.5	1.1	.39	0.042	110	180	350	450	450	75012	975	D-PULMONARY INJURY
	1.4	1.1	.42	0.039	99	170	340	440	440	75035	995	E-PULMONARY INJURY
	1.4	1.0		0.92	97	170		380+	190	72287	143	S-PULMONARY INJURY
	1.2	0.93	.37		90	150	300	400	400	76334	1662	D-PULMONARY INJURY
	1.3	0.95		0.84	92	160		340+	180	72287	143	S-PULMONARY INJURY
	1.2	0.92	.38	0.17	84	150	290	410+	360	74018	612	S-PULMONARY INJURY
										76345	1666	S-HEPATIC ATROPHY AND FIBROSIS
										72350	210	S-NORMAL
										75043	999	S-NORMAL
										73127	353	S-NORMAL
										72292	149	S-NORMAL
										72290	147	S-NORMAL
	1.8	1.4	.57	0.56	120	210	440	590+	440	73133	367	D-PULMONARY INJURY
	1.4	1.1	.39	0.065	98	170	330	450+	420	74297	896	E-PULMONARY INJURY
	1.3	1.0	.41	0.016	94	160	320	440+	430	75316	1275	D-PULMONARY INJURY
	1.2	0.83	.32		88	150	280	360	360	81068	3219	E-CARCINOMA,LUNG
	1.3	0.94	.33		91	160	300	390	390	78096	2155	D-PULMONARY INJURY
	1.1	0.87	.34	0.016	80	140	280	370	370	75226	1190	E-PULMONARY INJURY
										87224	5563	E-CHRONIC RENAL DISEASE; B.A. CARC.,LUNG
										86248	5222	E-NEPHROSCLEROSIS
										76122	1443	E-ASPIRATION PNEUMONIA

E.

MENT FINDINGS ARE INCLUDED.

A.12 ^{144}Ce in Fused Aluminosilicate Particles, Immature Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					DOSE RAT	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS
1022U	03-1922	F	D	76239	94	3.5	13.	44.	01	140.	480.	5.2	18.	6.1	2.3
675S	02-1136	F	B	73033	92	2.5	11.	28.	02	120.	310.	4.4	11.	5.2	2.2
671C	03-1132	M	C	73030	95	3.8	7.0	27.	03	84.	320.	3.1	12.	3.6	1.6
1027S	02-1925	F	D	76247	86	2.9	11.	32.	04	79.	230.	2.9	8.5	3.4	1.1
1024D	01-1922	M	E	76239	86	3.7	5.5	20.	05	74.	270.	2.7	10.	3.2	1.0
673D	03-1136	M	C	73033	95	2.2	10.	21.	06	73.	160.	2.7	5.9	3.2	0.86
673C	01-1136	M	C	73033	95	2.1	7.0	14.	07	70.	140.	2.6	5.2	3.0	0.80
672S	01-1133	F	B	73031	94	3.6	7.4	26.	08	64.	230.	2.4	8.5	2.8	0.96
1026A	01-1925	M	E	76247	88	3.4	8.1	27.	09	53.	180.	2.0	6.7	2.3	0.84
672B	03-1133	M	C	73031	94	3.4	9.6	33.	10	52.	180.	1.9	6.7	2.3	0.76
672C	02-1133	M	C	73031	94	3.2	5.5	18.	11	48.	150.	1.8	5.5	2.1	0.69
629A	01-1055	M	A	72221	92	2.8	10.	28.	12	38.	100.	1.4	3.7	1.6	0.63
1019A	02-1921	M	E	76232	91	3.5	7.8	27.	13	38.	130.	1.4	4.8	1.6	0.56
1033T	02-1927	F	D	76267	89	2.6	4.4	11.	14	37.	95.	1.4	3.5	1.5	0.51
1022S	02-1919	F	D	76231	86	3.2	3.0	9.3	15	34.	110.	1.3	4.1	1.6	0.56
675T	02-1137	F	B	73036	95	3.4	5.9	20.	16	28.	92.	1.0	3.4	1.2	0.43
627B	03-1054	M	A	72220	94	3.5	2.0	7.0	17	24.	85.	0.89	3.1	1.0	0.50
673S	01-1135	F	B	73032	94	2.1	1.9	3.7	18	21.	42.	0.78	1.6	0.91	0.28
1021V	01-1921	F	D	76232	88	3.3	1.3	4.4	19	18.	58.	0.67	2.1	0.78	0.25
673A	02-1132	M	C	73030	92	2.9	6.3	17.	20	16.	44.	0.59	1.6	0.69	0.19
672A	01-1132	M	C	73030	93	3.5	1.9	6.7	21	12.	41.	0.44	1.5	0.52	0.17
1033B	01-1927	M	E	76267	89	3.0	1.1	3.4	22	12.	35.	0.44	1.3	0.52	0.18
671S	02-1131	F	B	73029	94	2.8	1.3	3.7	23	11.	30.	0.41	1.1	0.48	0.14
630B	02-1054	M	A	72220	88	2.8	2.6	7.4	24	9.3	26.	0.34	0.96	0.40	0.16
1023S	03-1919	F	D	76231	86	2.4	0.44	1.0	25	6.7	16.	0.25	0.59	0.29	0.094
630A	01-1054	M	A	72220	88	3.8	0.55	2.1	26	6.0	23.	0.22	0.85	0.26	0.12
675B	04-1131	M	C	73029	88	2.7	0.67	1.8	27	5.0	13.	0.19	0.48	0.22	0.060
1016B	01-1919	M	E	76231	97	3.3	0.89	2.9	28	4.9	16.	0.18	0.59	0.21	0.078
673T	03-1131	F	B	73029	91	1.7	0.70	1.2	29	3.2	5.4	0.12	0.20	0.14	0.033
624D	04-1048	M	A	72209	90	2.7	0.31	0.81	30	3.1	8.1	0.11	0.30	0.13	0.051
671B	03-1130	M	C	73026	91	3.0	0.14	0.52	31	1.6	5.9	0.059	0.22	0.069	0.023
1017B	04-1918	M	E	76230	95	4.0	0.16	0.63	32	1.4	5.4	0.052	0.20	0.061	0.022
1018U	03-1918	F	D	76230	95	4.0	0.067	0.27	33	1.0	4.1	0.037	0.15	0.043	0.020
674T	01-1131	F	B	73029	88	2.1	0.17	0.35	34	0.87	1.8	0.032	0.067	0.038	0.0087
1021T	02-1918	F	D	76230	86	3.0	0.056	0.17	35	0.71	2.1	0.026	0.078	0.031	0.0091
623A	03-1048	M	A	72209	91	4.0	0.063	0.24	36	0.28	1.1	0.010	0.041	0.012	0.0063
1018B	01-1918	M	E	76230	95	3.8	0.0078	0.034	37	0.19	0.72	0.0070	0.027	0.0082	0.0027
669U	03-1125	F	B	73019	84	3.0	0.056	0.16	38	0.17	0.50	0.0063	0.019	0.0074	0.0023
668A	02-1125	M	C	73019	93	3.2	0.052	0.16	39	0.14	0.43	0.0052	0.016	0.0061	0.0019
1017S	01-1915	F	D	76229	94	3.2	0.011	0.035	40	0.12	0.38	0.0044	0.014	0.0052	0.0016
671A	02-1130	M	C	73026	91	2.7	0.036	0.096	41	0.089	0.24	0.0033	0.0089	0.0039	0.0012
624C	02-1048	M	A	72209	90	2.9	0.048	0.14	42	0.061	0.18	0.0023	0.0067	0.0027	0.00084
1021A	03-1921	M	E	76232	88	3.9	0.018	0.070	43	0.051	0.20	0.0019	0.0074	0.0022	0.00069
670S	01-1125	F	B	73019	89	1.7	0.048	0.081	44	0.024	0.040	0.00089	0.0015	0.0010	0.00033
624A	01-1048	M	A	72209	90	4.0	0.031	0.12	45	0.013	0.050	0.00048	0.0018	0.00055	0.00017
1033A	02-1926	M	E	76266	88	2.9	0.017	0.0048	46	0.011	0.032	0.00041	0.0012	0.00048	0.00015
1034U	01-1926	F	D	76266	85	2.8	0.0022	0.0059	47	0.0090	0.024	0.00032	0.00090	0.00038	0.00012
671D	01-1130	M	C	73026	91	2.9	0.024	0.067	48	0.0060	0.016	0.00022	0.00060	0.00026	0.000070
669V	03-1124	F	B	73018	90	2.6	0.032	0.081	49	0.0040	0.010	0.00015	0.00040	0.00017	0.000050
623B	01-1046	M	A	72208	90	3.5			C						
668B	01-1124	M	C	73018	92	3.1			C						
669S	02-1124	F	B	73018	90	3.4			C						
1013S	02-1913	F	D	76223	96	2.7			C						
1016A	01-1913	M	E	76223	89	3.4			C						

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDE

BETA RADIATION DOSE TO LUNG

IAL	DOSE RATE (GY/DAY) 60 DAYS	365 DAYS	AT DEATH	CUMULATIVE DOSE (GY) 60 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
	2.3		1.6	210.		550. +	270.	76330	91	D-PULMONARY INJURY
	2.2		1.4	190.		800. +	250.	73128	95	D-PULMONARY INJURY; CONG.HEART FAIL.
	1.6		1.3	140.		490. +	210.	73151	121	D-PULMONARY INJURY; CONG.HEART FAIL.
	1.1	.23	0.053	110.	260.	320. +	300.	78254	738	D-HEMANGIOSARCOMA,LUNG
	1.0	.27	0.073	100.	260.	330. +	310.	78208	700	E-HEMANGIOSARCOMA,LUNG
	0.86		0.78	100.		150. +	110.	73099	66	D-PULMONARY INJURY; CONG.HEART FAIL.
	0.80	.21	0.13	92.	210.	270. +	240.	74179	511	D-PULMONARY INJURY
	0.96	.26	0.090	88.	250.	310. +	290.	74355	689	E-HEMANGIOSARCOMA,LUNG
	0.84	.16		82.	190.	230.	230.	80100	1314	E-HEMANGIOSARCOMA,LUNG
	0.76	.21	0.081	78.	200.	250. +	230.	74284	618	E-HEMANGIOSARCOMA,LUNG
	0.69	.18	0.0044	72.	180.	220.	220.	77302	1732	D-HEMANGIOSARCOMA,SPLEEN
	0.63	.11		59.	130.	160.	160.	79330	2666	E-HEMANGIOSARCOMA,MUSCLE
	0.56	.14		50.	130.	180.	180.	80184	1413	D-HEMANGIOSARCOMA,TBLN
	0.51	.10		50.	120.	140.	140.	86266	3652	E-CARCINOMA,LUNG;HEMANGIOSARCOMA,LUNG
	0.56	.10		55.	120.	150.	150.	84196	2887	D-PLEURITIS,NOCARDIA
	0.43	.13	0.0052	40.	110.	150.	150.	76168	1227	E-HEMANGIOSARCOMA,TBLN.
	0.50	.095		46.	110.	130.	130.	79004	2341	E-HEMANGIOSARCOMA,DISSEMINATED
	0.28	.072		30.	72.	91.	91.	86125	4841	E-CARCINOMA,ANAL SAC
	0.25	.051		25.	58.	71.	71.	84123	2813	E-HEMANGIOSARCOMA,TBLN;B.A. CARC.,LUNG
	0.19	.055		21.	53.	67.	67.	82069	3326	E-LYMPHOSARC.,GENERAL;ADENOCARC.,LUNG
	0.17	.047	0.0025	17.	45.	57.	57.	77089	1520	D-EPILEPSY; HYPOTHRYROIDISM
	0.18	.037		17.	41.	51.	51.	84117	2772	E-HEMANGIOSARCOMA,TBLN
	0.14	.038		14.	36.	46.	46.	84278	4266	E-CARCINOMA,LUNG
	0.16	.025		15.	33.	40.	40.	85145	4674	D-CARCINOMA,LUNG
	0.094	.019		9.0	21.	27.	27.	86175	3597	E-CARCINOMA,LUNG
	0.12	.024		11.	27.	33.	33.	87128	5387	E-CARCINOMA,NASAL
	0.060	.015		7.0	15.	19.	19.	83212	3835	D-PANCREATIC ATROPHY
	0.078	.014		6.9	17.	20.	20.	91315	5563	D-CARCINOMA,LUNG
	0.033	.0087		3.3	8.1	11.	11.	85361	4715	D-INTERSTITIAL PNEUMONIA
	0.051	.0089		4.7	11.	13.	13.	87026	5296	E-MELANOMA,ORAL
9	0.023	.0065		2.5	6.3	8.0	8.0	89114	5932	E-MESOTHELIOMA,PULMONARY CARCINOMA
1	0.022	.0054		1.9	5.2	6.6	6.6	90141	5025	E-TRANSITIONAL CELL CARCINOMA,PROSTATE
3	0.020	.0049		1.7	4.5	6.5	6.5	91141	5390	D-INTERSTITIAL NEPHRITIS
8	0.0087	.0023		1.0	2.4	2.9	2.9	89090	5905	E-PAPILLARY ADENOCARCINOMA,LUNG
1	0.0091	.0020		0.89	2.1	2.7	2.7	89095	4614	E-MAMMARY COMPLEX ADENOCARCINOMA
2	0.0063	.0011		0.50	1.3	1.6	1.6	88007	5642	E-HEART BASE TUMOR,HEART
82	0.0027	.00090		0.23	0.67	0.98	0.98	84313	3005	D-FOCAL PNEUMONIA
74	0.0023	.00058		0.24	0.58	0.74	0.74	84291	4289	E-LYMPHOSARCOMA,VISCERAL
61	0.0019	.00046		0.19	0.46	0.59	0.59	88343	5802	E-CORONARY, PULMONARY THROMBOSES
52	0.0016	.00040		0.17	0.40	0.51	0.51	88243	4397	E-DEGENERATIVE MYOPATHY,ESOPHAGUS
39	0.0012	.00030		0.13	0.30	0.38	0.38	84163	4154	D-IMPACTION,GALL BLADDER
27	0.00084	.00021		0.088	0.21	0.27	0.27	81191	3270	E-POLIOENCEPHALOMALACIA, SPINAL CORD
22	0.00069	.00017		0.072	0.17	0.22	0.22	86244	3665	D-LEIOMYOSARCOMA, INTESTINE
10	0.00033	.000082		0.034	0.083	0.11	0.11	87012	5106	E-CHRONIC INTERSTITIAL NEPHRITIS
055	0.00017	.000042		0.018	0.043	0.054	0.054	85225	4765	E-CIRRHOSIS,LIVER
048	0.00015	.000037		0.015	0.044	0.047	0.047	86283	3670	D-PNEUMONIA
038	0.00012	.000029		0.012	0.029	0.037	0.037	90233	5081	E-ADENOCARCINOMA, MAMMARY GLAND
026	0.000070	.000019		0.0080	0.019	0.024	0.024	88061	5513	E-MALIGNANT MELANOMA,ORAL CAVITY
017	0.000050	.000013		0.0060	0.013	0.017	0.017	87242	5338	D-PNEUMONIA
								84027	4202	E-HEART FAILURE
								87267	5362	D-HEART FAILURE
								84214	4213	E-LYMPHOSARCOMA,GENERALIZED
								87220	4015	D-ENDOCARDITIS
								80140	1378	E-VERTEBRAL DISC RUPTURE

S ARE INCLUDED.

A.13 ^{144}Ce in Fused Aluminosilicate Particles, Immature Sacrifice Study

DOG IDENTIFICATION			INHALATION EXPOSURE			I.B.B.		I.L.B.				BETA RADIATION DOSE RATE (GY/DAY)				
TATTOO	AN-EXPT	SEX	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	120 DAYS	365 DAYS	AT DEATH
672T	04-1132	F	73030	93	3.0	5.2	15.	46	140	1.7	5.2	2.2	.63	.39	.15	.084
629B	03-1055	M	72221	92	2.7	10.	27.	43	120	1.6	4.4	1.7	.88	.46		.42
673U	01-1137	F	73036	98	1.7	5.2	8.9	37	62	1.4	2.3	1.2	.42			.29
631S	03-1063	F	72228	91	1.8	1.4	2.4	11	19	0.41	0.7	0.48	.17	.10	.035	

UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE I

BETA RADIATION DOSE TO LUNG

	DOSE RATE (GY/DAY)				CUMULATIVE DOSE (GY)							
TIAL	60 DAYS	120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
2	.63	.39	.15	.084	69	98	160	200+	170	74179	514	S-PULMONARY INJURY
7	.88	.46		.42	75	110		160+	120	72350	129	S-
2	.42			.29	44			130+	51	73117	81	S-
68	.17	.10	.035		16	24	38	38	38	82258	3241	S-

TION EXPOSURE.

VELY. PROMINENT FINDINGS ARE INCLUDED.

A.14 ^{144}Ce in Fused Aluminosilicate Particles, Aged Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					BETA DOSE RATE (GY/DAY		
TATTOO	AM-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	120 DAYS	365 DAYS
FD-49	02-982	F	B	72040	3748	9.5	5.5	52.	01	75.	710	2.8	26.	4.4	3.0	2.2	
FD-40	02-991	F	E	72055	3565	12.0	6.3	74.	02	67.	800	2.5	30.	4.0	3.2	2.5	
FD-98	01-987	F	C	72046	3686	10.9	3.7	41.	03	56.	610	2.1	23.	3.3	2.5	2.0	
FD-108	03-987	F	D	72046	3537	11.7	5.9	70.	04	51.	600	1.9	22.	3.0	2.3	1.8	
FD-118	01-990	F	F	72054	3318	6.7	7.0	44.	05	50.	330	1.9	12.	3.0	2.2	1.7	
FD-145	03-982	F	A	72040	3840	10.5	2.7	28.	06	40.	420	1.5	16.	2.4	1.8	1.4	
73B	01-1685	M	H	75252	3814	11.5	5.9	70.	07	37.	420	1.4	16.	2.1	1.6	1.2	.43
176A	02-1689	M	K	75258	3392	11.9	2.3	28.	08	35.	410	1.3	15.	2.0	1.5	1.2	.45
211C	03-1690	M	L	75259	3250	11.3	2.5	28.	09	33.	370	1.2	14.	1.9	1.5	1.2	.45
105A	03-1687	M	I	75254	3677	13.2	2.3	30.	10	32.	420	1.2	16.	1.8	1.4	1.1	.41
151A	03-1688	M	J	75255	3514	13.6	4.4	59.	11	27.	370	1.0	14.	1.5	1.2	0.96	.39
FD-12	02-987	F	C	72046	3714	14.5	4.4	67.	12	27.	400	1.0	15.	1.6	1.1	0.83	
71A	02-1686	M	H	75253	3819	13.0	2.6	33.	13	25.	320	0.93	12.	1.4	1.1	0.88	
FD-7	01-991	F	E	72055	3511	10.2	4.4	48.	14	25.	250	0.93	9.3	1.5	1.1	0.84	
FD-100	01-983	F	B	72041	3841	8.8	3.0	26.	15	23.	200	0.85	7.4	1.4	1.0	0.78	
FD-121	02-990	F	F	72054	3119	16.0	3.3	52.	16	23.	360	0.85	13.	1.4	1.0	0.78	
FD-94	03-990	F	D	72054	3461	6.7	2.3	15.	17	22.	150	0.81	5.5	1.3	0.98	0.75	.28
FD-31	04-982	F	A	72040	3859	10.7	1.4	14.	18	22.	230	0.81	8.5	1.3	0.95	0.72	
FD-103	01-982	F	B	72040	3705	9.4	1.0	9.3	19	20.	190	0.74	7.0	1.2	0.88	0.70	
166A	03-1689	M	K	75258	3417	12.2	1.4	18.	20	17.	210	0.63	7.8	0.97	0.75	0.59	.22
116B	02-1688	M	J	75255	3638	10.7	1.4	15.	21	16.	170	0.59	6.3	0.91	0.70	0.55	.21
214D	01-1690	M	L	75259	3218	10.1	1.3	13.	22	16.	170	0.59	6.3	0.91	0.70	0.55	.21
FD-32	03-984	F	D	72045	3542	7.8	1.4	11.	23	14.	110	0.52	4.1	0.83	0.64	0.50	.20
FD-47	02-984	F	C	72045	3585	8.4	1.0	8.9	24	14.	120	0.52	4.4	0.83	0.58	0.44	
FD-190	01-1376	M	G	74036	3844	9.7	1.5	14.	25	14.	130	0.52	4.8	0.83	0.58	0.46	.17
FD-15	01-989	F	F	72053	3273	12.3	2.6	31.	26	13.	160	0.48	5.9	0.77	0.57	0.44	.15
FD-30	02-983	F	A	72041	3877	11.4	1.9	21.	27	13.	150	0.48	5.5	0.77	0.62	0.49	.19
23A	03-1374	M	G	74035	3501	14.1	1.9	26.	28	12.	170	0.44	6.3	0.71	0.55	0.44	
FD-185	02-1374	M	G	74035	3864	11.2	5.5	63.	29	12.	140	0.44	5.2	0.71	0.50	0.36	.12
FD-153	02-989	F	E	72053	3320	8.6	1.7	15.	30	11.	96	0.41	3.6	0.65	0.49	0.38	.15
FD-154	04-989	F	F	72053	3313	11.4	1.0	11.	31	9.0	100	0.33	3.7	0.53	0.38	0.29	.11
FD-95	01-984	F	C	72045	3563	7.4	0.67	4.8	32	8.5	62	0.31	2.3	0.50	0.37	0.28	.11
116A	01-1688	M	J	75255	3638	11.9	0.63	7.4	33	8.4	100	0.31	3.7	0.48	0.38	0.30	.11
109B	02-1687	M	I	75254	3671	10.9	0.70	7.8	34	8.3	90	0.31	3.3	0.47	0.35	0.26	.079
FD-131	01-1374	M	G	74035	3889	10.6	0.55	5.9	35	8.3	88	0.31	3.3	0.49	0.37	0.29	.11
165B	01-1689	M	K	75258	3419	14.0	0.81	11.	36	8.0	110	0.30	4.1	0.46	0.36	0.28	.11
FD-48	04-984	F	D	72045	3544	12.2	1.3	15.	37	7.7	94	0.28	3.5	0.46	0.3[illegible]	0.27	.10
FD-38	03-983	F	B	72041	3326	8.7	0.85	7.4	38	7.4	64	0.27	2.4	0.44	0.34	0.27	.11
FD-104	04-983	F	A	72041	3931	12.3	0.89	11.	39	6.4	79	0.24	2.9	0.38	0.27	0.21	.081
181C	02-1690	M	L	75259	3362	10.2	1.6	16.	40	5.9	60	0.22	2.2	0.34	0.26	0.21	.078
FD-150	03-989	F	E	72053	3320	9.9	0.89	8.5	41	5.5	54	0.20	2.0	0.33	0.25	0.20	.076
FD-307	01-1686	M	H	75253	3752	12.9	0.12	1.6	42	2.4	31	0.089	1.1	0.14	0.11	0.087	.033
FD-101	05-981	F	A	72039	3842	9.9			C								
FD-117	01-981	F	C	72039	3679	6.2			C								
FD-147	02-981	F	D	72039	3525	8.9			C								
FD-149	04-981	F	F	72039	3261	8.2			C								
FD-4	03-981	F	E	72039	3499	14.7			C								
FD-6	06-981	F	B	72039	3815	10.6			C								
2C	01-1379	M	G	74038	3777	12.0			C								
111A	05-1684	M	I	75248	3655	9.8			C								
114D	01-1684	M	J	75248	3634	12.1			C								
178A	04-1684	M	K	75248	3380	9.6			C								
225B	02-1684	M	L	75248	3153	12.2			C								
59C	03-1684	M	H	75248	3865	14.9			C								

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLUD

BETA RADIATION DOSE TO LUNG

DOSE RATE (GY/DAY)				CUMULATIVE DOSE (GY)					DEATH	DAYS TO	
60 DAYS	120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENT. INFIN.	TO DEATH	DATE	DEATH	COMMENT
.0	2.2		1.4	210.	370		760+	500	72237	197	D-PULMONARY INJURY
.2	2.5		1.2	210.	380		1100+	740	73009	320	D-PULMONARY INJURY
.5	2.0		1.2	170.	310		840+	530	72307	261	D-PULMONARY INJURY
.3	1.8		1.1	160.	280		710+	440	72279	233	E-PULMONARY INJURY
.2	1.7		0.87	150.	260		650+	450	72327	273	E-PULMONARY INJURY
.8	1.4		0.99	130.	220		560+	330	72249	209	D-PULMONARY INJURY
.6	1.2	.43	0.23	110.	200	380	480+	430	77024	503	E-PULMONARY FIBROSIS
.5	1.2	.45		110.	190	370	490	490	79078	1281	D-CARCINOMA,LUNG
.5	1.2	.45	0.066	100.	180	370	480+	460	78013	850	E-PULMONARY INJURY
.4	1.1	.41	0.20	95.	170	340	440+	390	77068	545	D-PULMONARY INJURY
.2	0.96	.39	0.37	80.	140	300	400+	300	76264	374	E-PULMONARY INJURY; CONG.HEART FAIL.
.1	0.83		0.52	79.	140		300+	200	72260	214	D-PULMONARY INJURY
.1	0.88		0.50	75.	130		360+	230	76152	264	D-PULMONARY INJURY
.1	0.84		0.49	74.	130		830+	220	72305	250	D-PULMONARY INJURY; CONG.HEART FAIL.
.0	0.78		0.037	71.	120	240	320+	310	74253	943	D-PULMONARY INJURY
.0	0.78		0.45	68.	120		310+	200	72309	255	D-PULMONARY INJURY
.98	0.75	.28	0.017	68.	120	230	310	310	75165	1207	D-PULMONARY INJURY
.95	0.72		0.34	66.	120		270+	200	72320	280	D-PULMONARY INJURY; CONG.HEART FAIL.
.88	0.70		0.25	60.	110	220	290+	220	73064	390	D-PULMONARY INJURY
.75	0.59	.22		52.	92	180	240	240	82110	2409	E-ADENOCARCINOMA,NASAL;CARCINOMA,LUNG
.70	0.55	.21		49.	86	170	230	230	78325	1166	D-HEMORRHAGIC ENTERITIS
.70	0.55	.21		49.	86	170	230	230	82211	2509	E-GRANULOMATOUS PNEUMONIA;MENINGIOMA
.64	0.50	.20		44.	78	160	220	220	77067	1849	D-LEIOMYOMA,BLADDER;PULMONARY INJURY
.58	0.44		0.19	41.	71		180+	130	73009	330	D-ADENOCARCINOMA,MAMMARY GLAND
.58	0.46	.17	0.00090	41.	72	140	190	190	78269	1694	E-NEPHROSCLEROSIS;CARCINOMA,PANCREAS
.57	0.44	.15	0.12	40.	70	130	170+	140	73106	419	D-CONGESTIVE HEART FAILURE
.62	0.49	.19	0.17	42.	75	150	200+	150	73058	383	D-CONGESTIVE HEART FAILURE
.55	0.44		0.066	37.	67		180+	120	74355	320	D-PULMONARY INJURY; HYPOTHYROID
.50	0.36	.12	0.0027	35.	61	120	160	160	77322	1383	D-PULMONARY THROMBOSIS
.49	0.38	.15	0.0038	34.	59	120	150	150	75295	1338	D-CONGESTIVE HEART FAILURE
.38	0.29	.11	0.038	27.	47	92	120+	110	73356	669	D-PULMONARY INJURY
.37	0.28	.11		25.	45	88	120	120	77256	2038	E-CHRONIC PYELONEPHRITIS
.38	0.30	.11		26.	46	93	120	120	80036	1607	E-MALIGNANT MELANOMA, MOUTH
.35	0.26	.079		24.	43	86	110	110	79016	1223	E-LYMPHOMA,VISCERAL
.37	0.29	.11	0.00060	25.	45	90	120	120	78265	1691	E-SEMINOMA;BRONCHIOLOALVEOLAR CARCINOMA
.36	0.28	.11		25.	44	89	110	110	81225	2159	E-CARDIAC INSUFFICIENCY
.3/	0.27	.10	0.012	23.	42	83	110	110	74218	904	D-ADENOCARCINOMA,MAMMARY GLAND
.34	0.27	.11	0.0018	23.	41	85	120	120	76079	1499	E-ADENOMA,ADRENAL;BRONCHIOLOALV. CARC.
.27	0.21	.081	0.00008	19.	33	67	87	87	77281	2067	E-NEPHRITIS;CONGESTIVE HEART FAILURE
.26	0.21	.078		18.	32	64	84	84	82286	2584	E-SWEAT GLAND ADENOCARCINOMA
.25	0.20	.076	0.00003	17.	30	61	80	80	78236	2375	E-SQUAM. CELL CARC.,ORAL;B-A-CARCINOMA
.11	0.087	.033		7.5	13	26	36	36	79110	1318	E-DISC PROTRUSION
									74342	1034	D-BILATERAL ADRENAL HYPERPLASIA
									77363	2151	D-PYELONEPHRITIS
									74151	843	D-PYOMETRA
									75114	1171	D-ADENOCARCINOMA,MAMMARY GLAND
									77195	1983	E-FIBROBLASTIC OSTEOSARCOMA,BONE
									73265	592	D-ADENOCARCINOMA,MAMMARY GLAND
									77033	1091	D-BRONCHIOLOALVEOLAR CARCINOMA
									79358	1571	D-RENAL FIBROSIS
									82043	2352	E-DISC PROLAPSE;CARCINOMA,LUNG
									83052	2726	E-CONGESTIVE HEART FAILURE
									79302	1515	D-PLEURITIS (NOCARDIA SP.)
									76275	392	D-LOBAR PNEUMONIA

DINGS ARE INCLUDED.

A.15 ^{90}Sr in Fused Aluminosilicate Particles, Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					DOSE	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS
417A	04-828	M	H	70288	379	10.6	9.3	100.	001	96.	1014.	3.6	38.	5.0	4.5
415T	01-828	F	I	70288	396	9.2	4.4	41.	002	90.	832.	3.3	31.	4.8	3.9
435A	01-856	M	J	71032	391	11.5	5.2	63.	003	77.	885.	2.8	33.	4.1	3.3
393A	01-792	M	C	70218	427	10.3	3.7	37.	004	74.	763.	2.7	28.	3.9	3.3
416B	02-828	M	H	70288	382	11.6	7.8	89.	005	74.	855.	2.7	32.	3.9	3.5
403A	03-809	M	E	70238	396	7.0	5.2	36.	006	74.	515.	2.7	19.	3.9	3.1
397T	04-792	F	D	70218	409	8.6	5.5	48.	007	73.	629.	2.7	23.	3.9	3.0
500B	04-964	M	L	71300	369	8.6	5.5	48.	008	71.	608.	2.6	22.	3.7	2.8
417T	03-828	F	I	70288	379	9.5	11.	100.	009	70.	661.	2.6	24.	3.7	2.9
403S	04-809	F	F	70238	396	7.0	5.2	36.	010	68.	468.	2.5	17.	3.6	2.4
403U	01-809	F	F	70238	396	6.8	5.5	37.	011	67.	454.	2.5	17.	3.5	2.8
398U	02-792	F	D	70218	393	6.8	3.5	24.	012	66.	452.	2.4	17.	3.5	2.8
432T	01-855	F	K	71029	413	8.2	7.0	59.	013	65.	530.	2.4	20.	3.4	2.7
433A	02-854	M	J	71028	411	11.0	4.1	48.	014	65.	710.	2.4	26.	3.4	2.7
405X	01-824	F	G	70266	417	8.6	4.8	41.	015	63.	541.	2.3	20.	3.3	2.8
355S	01-703	F	B	70036	424	8.6	5.5	48.	016	62.	536.	2.3	20.	3.3	2.6
355B	02-703	M	A	70036	424	9.4	3.7	35.	017	58.	544.	2.1	20.	3.0	2.5
398A	03-792	M	C	70218	393	11.4	3.0	34.	018	57.	652.	2.1	24.	3.0	2.5
408T	02-824	F	G	70266	409	8.6	3.7	33.	019	55.	473.	2.0	18.	2.9	2.5
361T	03-701	F	B	70034	415	8.4	3.3	28.	020	53.	444.	2.0	16.	2.8	2.4
402D	02-809	M	E	70238	397	6.7	7.0	48.	021	53.	354.	2.0	13.	2.8	2.4
357A	01-702	M	A	70035	421	9.8	5.5	52.	022	53.	515.	2.0	19.	2.8	2.3
418S	03-827	F	I	70286	365	10.0	3.3	33.	023	51.	514.	1.9	19.	2.7	2.4
437D	03-855	M	J	71029	382	8.3	3.7	32.	024	51.	423.	1.9	16.	2.7	2.0
494A	03-964	M	L	71300	404	9.4	3.7	36.	025	50.	474.	1.9	18.	2.7	1.9
411A	01-827	M	H	70286	421	14.2	9.6	130.	026	49.	699.	1.8	26.	2.6	2.4
431U	02-855	F	K	71029	421	7.2	8.9	67.	027	48.	348.	1.8	13.	2.5	2.2
402A	01-808	M	E	70237	396	9.5	2.1	20.	028	42.	402.	1.6	15.	2.2	1.9
400S	04-808	F	F	70237	404	9.1	3.1	28.	029	41.	370.	1.5	14.	2.1	1.7
433S	04-854	F	K	71028	411	9.0	2.3	21.	030	38.	339.	1.4	13.	2.0	1.7
411T	03-824	F	G	70266	401	7.6	2.6	20.	031	37.	284.	1.4	11.	2.0	1.8
497B	02-964	M	L	71300	375	8.8	1.8	16.	032	35.	308.	1.3	11.	1.8	1.4
396T	03-790	F	D	70216	417	8.6	3.0	25.	033	33.	282.	1.2	10.	1.7	1.3
398D	02-790	M	C	70216	391	9.5	1.9	18.	034	32.	305.	1.2	11.	1.7	1.4
751A	03-1581	M	O	74338	429	10.0	1.7	17.	035	31.	309.	1.1	11.	1.6	1.4
354W	02-702	F	B	70035	425	7.5	2.3	17.	036	30.	224.	1.1	8.3	1.6	1.3
355A	04-701	M	A	70034	422	10.6	3.6	37.	037	24.	257.	0.89	9.5	1.3	1.1
433C	01-854	M	J	71028	411	9.8	1.1	10.	038	24.	234.	0.89	8.7	1.3	1.1
748S	01-1580	F	N	74337	446	7.6	1.5	11.	039	23.	171.	0.85	6.3	1.2	1.0
414T	04-827	F	I	70286	397	7.0	2.0	14.	040	21.	150.	0.78	5.5	1.1	0.97
416C	02-827	M	H	70286	380	10.7	1.6	17.	041	21.	223.	0.78	8.3	1.1	0.92
759S	03-1586	F	P	74347	415	10.0	1.7	17.	042	21.	208.	0.78	7.7	1.1	0.91
430S	03-854	F	K	71028	423	7.7	1.1	8.5	043	21.	160.	0.78	5.9	1.1	0.90
399U	03-808	F	F	70237	407	7.2	2.0	14.	044	19.	137.	0.70	5.1	1.0	0.86
401B	02-808	M	E	70237	403	9.0	1.9	17.	045	19.	169.	0.70	6.3	0.98	0.85
398B	01-790	M	C	70216	391	11.2	1.0	12.	046	18.	204.	0.67	7.5	0.96	0.82
404S	01-823	F	G	70265	422	8.6	0.89	7.4	047	17.	150.	0.63	5.5	0.92	0.77
748A	02-1581	M	M	74338	447	8.2	0.93	7.4	048	16.	134.	0.59	5.0	0.86	0.78
354A	01-701	M	A	70034	424	10.4	1.8	19.	049	15.	161.	0.55	6.0	0.81	0.70
495C	01-964	M	L	71300	385	8.0	0.89	7.0	050	15.	119.	0.55	4.4	0.78	0.65
362T	02-701	F	B	70034	413	6.8	1.3	8.9	051	15.	101.	0.55	3.7	0.78	0.68
397S	04-790	F	D	70216	407	8.3	0.96	8.1	052	15.	121.	0.55	4.5	0.76	0.65
413B	02-826	M	H	70285	409	10.9	0.85	9.3	053	14.	148.	0.52	5.5	0.71	0.60

BETA RADIATION DOSE TO LUNG

DOSE RATE (GY/DAY)				CUMULATIVE DOSE (GY)							
60 DAYS	120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENTIAL 5000 DAYS	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
.5	4.3		4.2	280.	550.		11000. +	870.	71118	195	D-PULMONARY INJURY
.9	3.4		3.1	260.	470.		13000. +	790.	71143	220	D-PULMONARY INJURY
.3	3.0		2.7	220.	410.		11000. +	720.	71263	231	E-PULMONARY INJURY
.3	2.8		2.5	220.	400.		1400. +	500.	71012	159	D-PULMONARY INJURY
.5	3.2		3.0	210.	420.		3400. +	620.	71107	184	D-PULMONARY INJURY
.1	2.7	2.1	2.1	210.	380.	940.	4700. +	990.	71259	386	D-PULMONARY INJURY
.0	2.6		2.3	200.	360.		9600. +	600.	71071	218	D-PULMONARY INJURY
.8	2.4		2.1	190.	350.		8900. +	640.	72190	255	D-PULMONARY INJURY
.9	2.6		2.4	200.	360.		10000. +	730.	71190	267	E-PULMONARY INJURY
.4	2.2		1.8	150.	290.		1700. +	510.	71105	232	D-PULMONARY INJURY
.8	2.5		2.2	190.	350.		4700. +	670.	71131	258	D-PULMONARY INJURY
.8	2.6		2.0	180.	340.		2500. +	820.	71182	329	D-PULMONARY INJURY
.7	2.3		1.9	180.	330.		5800. +	640.	71297	268	D-PULMONARY INJURY
.7	2.5		2.3	180.	340.		10000. +	650.	71280	252	E-PULMONARY INJURY
.8	3.4		2.1	180.	340.		870. +	610.	71144	243	D-PULMONARY INJURY
.6	2.3		1.9	180.	320.		4500. +	780.	71013	342	D-PULMONARY INJURY
.5	2.2	1.8	1.8	170.	310.	780.	7800. +	800.	71044	373	D-PULMONARY INJURY
.5	2.2		2.1	160.	300.		7800. +	640.	71135	282	D-PULMONARY INJURY
.5	2.2		2.0	160.	300.		8300. +	540.	71139	238	D-PULMONARY INJURY
.4	2.2		1.9	150.	290.		3000. +	590.	70299	265	D-PULMONARY INJURY
.4	2.1		1.7	150.	290.		3700. +	620.	71173	300	D-PULMONARY INJURY
.3	2.0		1.6	150.	280.		6900. +	670.	71011	341	D-PULMONARY INJURY
.4	2.1		1.7	150.	290.		1200. +	440.	71122	201	D-PULMONARY INJURY
.0	1.7	1.2	1.2	140.	250.	600.	1600. +	620.	72040	376	E-PULMONARY INJURY
.9	1.4		0.67	140.	240.		750. +	420.	72245	310	D-PULMONARY INJURY
.4	2.2		2.0	150.	290.		1800. +	450.	71122	201	D-PULMONARY INJURY
.2	1.9		1.7	140.	260.		6900. +	450.	71255	226	D-PULMONARY INJURY
.9	1.6		1.3	120.	220.		5400. +	530.	71212	340	D-PULMONARY INJURY
.7	1.5		1.3	110.	210.		3700. +	430.	71158	286	D-PULMONARY INJURY
.7	1.5		1.3	110.	200.		3500. +	420.	71307	279	D-PULMONARY INJURY
.8	1.6		1.2	110.	210.		1000. +	400.	71160	259	D-PULMONARY INJURY
.4	1.2	0.76	0.51	96.	170.	390.	1200. +	660.	73357	788	D-HEMANGIOSARCOMA,LUNG
.3	1.2	0.81	0.52	90.	160.	400.	1000. +	630.	72204	718	D-HEMANGIOSARCOMA,LUNG
.4	1.2	0.89	0.70	93.	170.	420.	1500. +	650.	72130	644	E-HEMANGIOSARCOMA,LUNG
.4	1.2	0.93	0.67	89.	170.	420.	1500. +	720.	76355	747	E-HEMANGIOSARCOMA,LUNG
.3	1.1	0.86	0.80	85.	160.	400.	1700. +	490.	71147	477	D-PULMONARY INJURY
.1	0.98	0.65	0.44	71.	130.	330.	1000. +	520.	72019	715	D-HEMANGIOSARCOMA,LUNG
.1	1.0	0.78	0.58	71.	140.	350.	1200. +	570.	72356	693	E-HEMANGIOSARCOMA,LUNG
.0	0.91	0.69	0.44	65.	120.	310.	1000. +	580.	77084	843	E-HEMANGIOSARCOMA,LUNG
.97	0.86	0.60	0.38	63.	120.	290.	1000. +	540.	73064	874	D-HEMANGIOSARCOMA,LUNG
.92	0.79	0.50	0.24	60.	110.	260.	840. +	530.	73318	1128	E-EPIDERMOID CARC.;HEMANGIOSARC.,LUNG
.91	0.78	0.54	0.37	60.	110.	270.	1100. +	500.	77133	882	E-HEMANGIOSARCOMA,LUNG
.90	0.79	0.59	0.41	59.	110.	270.	970. +	490.	73106	809	E-HEMANGIOSARCOMA,LUNG
.86	0.74	0.50	0.27	56.	100.	250.	930. +	540.	73311	1170	E-HEMANGIOSARCOMA,LUNG
.85	0.78	0.60	0.30	55.	100.	270.	850. +	560.	73166	1025	D-HEMANGIOSARCOMA,LUNG
.82	0.73	0.54	0.29	53.	99.	250.	820. +	520.	73153	1033	E-HEMANGIOSARC. AND B.A.CARC.,LUNG
.77	0.66	0.45	0.087	50.	93.	230.	660. +	580.	76042	1968	D-HEMANGIOSARCOMA,HEART
.78	0.71	0.50	0.15	49.	94.	240.	870. +	660.	80078	1931	D-PULMONARY INJURY
.70	0.61	0.40	0.18	45.	84.	200.	660. +	430.	73152	1214	E-HEMANG.,LUNG;SQUAM-CELL CARC,LUNG
.65	0.55	0.36	0.11	43.	78.	190.	600. +	480.	76295	1821	E-HEMANGIOSARC.,SPLEEN; B.A.CARCINOMA
.68	0.60	0.41	0.18	44.	82.	200.	600. +	430.	73123	1185	D-HEMANGIOSARCOMA,LUNG
.65	0.56	0.38	0.064	42.	78.	190.	600. +	540.	77032	2373	D-PULMONARY INJURY
.60	0.51	0.30	0.15	39.	72.	170.	630. +	340.	74037	1213	D-HEMANGIOSARCOMA,LUNG

A.15 ^{90}Sr in Fused Aluminosilicate Particles, Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					DOSE RATE		
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	1 DAY
415V	01-826	F	I	70285	393	7.5	0.85	6.7	054	13.	99.	0.48	3.7	0.70	0.59	0.5
405A	02-806	M	E	70236	387	9.7	0.78	7.8	055	9.4	92.	0.35	3.4	0.50	0.41	0.3
438A	04-853	M	J	71027	376	9.9	0.74	7.4	056	9.2	91.	0.34	3.4	0.48	0.39	0.3
358T	01-704	F	B	70037	420	9.0	0.89	7.8	057	9.1	82.	0.34	3.0	0.48	0.44	0.4
411S	03-823	F	G	70265	400	8.1	0.85	7.0	058	8.6	70.	0.32	2.6	0.45	0.41	0.3
413C	03-826	M	H	70285	409	12.2	0.44	5.2	059	8.5	103.	0.31	3.8	0.45	0.38	0.3
393C	02-789	M	C	70215	424	8.2	0.41	3.4	060	7.9	65.	0.29	2.4	0.42	0.37	0.3
393T	03-789	F	D	70215	424	6.6	0.55	3.2	061	7.9	52.	0.29	1.9	0.42	0.34	0.3
399T	01-806	F	F	70236	406	8.0	0.48	4.1	062	7.7	61.	0.28	2.3	0.40	0.36	0.3
367B	04-700	M	A	70033	385	9.6	1.0	8.5	063	7.6	73.	0.28	2.7	0.40	0.36	0.3
754T	02-1580	F	N	74337	410	7.0	0.41	2.7	064	7.4	52.	0.27	1.9	0.39	0.34	0.3
494D	01-963	M	L	71299	403	8.0	0.44	3.6	065	6.8	55.	0.25	2.0	0.36	0.33	0.3
430V	02-853	F	K	71027	422	7.2	0.81	5.9	066	6.6	48.	0.24	1.8	0.35	0.31	0.2
413S	04-826	F	I	70285	409	10.4	0.59	6.3	067	6.6	69.	0.24	2.6	0.35	0.29	0.2
405S	02-823	F	G	70265	416	9.9	0.52	5.2	068	5.7	57.	0.21	2.1	0.30	0.27	0.2
759C	01-1586	M	Q	74347	415	10.9	0.36	4.1	069	5.7	62.	0.21	2.3	0.30	0.26	0.2
352B	02-704	M	A	70037	433	7.9	0.31	2.5	070	5.4	43.	0.20	1.6	0.28	0.25	0.2
755A	01-1581	M	O	74338	409	7.1	0.25	1.8	071	5.3	38.	0.20	1.4	0.28	0.24	0.2
754B	03-1580	M	M	74337	410	8.1	0.34	2.7	072	5.2	42.	0.19	1.6	0.27	0.25	0.2
431T	01-853	F	K	71027	419	6.6	0.37	2.4	073	4.9	33.	0.18	1.2	0.26	0.22	0.2
494B	02-963	M	L	71299	403	9.4	0.41	3.7	074	4.9	46.	0.18	1.7	0.26	0.21	0.1
360T	02-700	F	B	70033	414	7.9	0.93	7.4	075	4.5	35.	0.17	1.3	0.23	0.19	0.1
399S	04-806	F	F	70236	406	9.7	0.31	3.1	076	4.3	41.	0.16	1.5	0.22	0.20	0.1
398S	04-789	F	D	70215	390	9.6	0.36	3.4	077	4.2	40.	0.16	1.5	0.22	0.19	0.1
435C	03-853	M	J	71027	386	9.0	0.25	2.3	078	4.1	37.	0.15	1.4	0.21	0.18	0.1
393D	01-789	M	C	70215	424	10.5	0.27	2.9	079	4.1	43.	0.15	1.6	0.21	0.19	0.1
403B	03-806	M	E	70236	394	7.3	0.26	1.9	080	3.9	28.	0.14	1.0	0.20	0.18	0.1
758U	04-1586	F	P	74347	417	7.0	0.48	3.3	081	3.5	24.	0.13	0.89	0.18	0.15	0.1
755U	02-1586	F	R	74347	418	6.2	0.48	3.1	082	2.6	16.	0.096	0.59	0.14	0.12	0.1
762B	01-1583	M	Q	74344	407	6.7	0.14	0.93	083	1.6	11.	0.059	0.41	0.085	0.074	0.0
756C	02-1584	M	Q	74345	416	11.0	0.085	0.96	084	1.5	17.	0.056	0.63	0.081	0.073	0.0
751U	03-1583	F	P	74344	435	10.2	0.089	0.89	085	1.5	16.	0.056	0.59	0.080	0.068	0.0
749S	02-1577	F	N	74330	430	8.2	0.093	0.74	086	1.5	12.	0.056	0.44	0.079	0.071	0.0
749B	03-1579	M	M	74336	436	8.8	0.093	0.81	087	1.5	13.	0.056	0.48	0.076	0.064	0.0
762U	01-1584	F	R	74345	408	6.9	0.11	0.81	088	1.2	8.5	0.044	0.31	0.065	0.058	0.0
756B	04-1578	M	O	74331	402	10.6	0.085	0.93	089	1.0	11.	0.037	0.41	0.054	0.048	0.0
748B	02-1579	M	O	74336	445	8.7	0.074	0.63	090	0.98	8.5	0.036	0.31	0.051	0.047	0.0
755S	04-1584	F	R	74345	416	10.0	0.10	1.0	091	0.90	9.0	0.033	0.33	0.047	0.044	0.0
754S	04-1585	F	P	74346	419	8.3	0.15	1.2	092	0.80	6.6	0.030	0.24	0.042	0.038	0.0
752A	03-1578	M	M	74331	414	6.7	0.056	0.37	093	0.80	5.3	0.030	0.20	0.042	0.039	0.0
751T	03-1577	F	N	74330	421	9.3	0.085	0.78	094	0.62	5.8	0.023	0.21	0.033	0.029	0.0
754A	01-1579	M	M	74336	409	9.7	0.024	0.23	095	0.32	3.1	0.012	0.11	0.017	0.016	0.0
751V	04-1583	F	R	74344	435	8.4	0.031	0.26	096	0.31	2.6	0.011	0.096	0.016	0.015	0.0
759D	01-1585	M	Q	74346	414	9.1	0.033	0.30	097	0.29	2.7	0.011	0.10	0.015	0.014	0.0
762V	03-1584	F	R	74345	408	6.3	0.067	0.41	098	0.27	1.7	0.010	0.063	0.014	0.013	0.0
758T	03-1585	F	P	74346	416	7.0	0.017	0.12	099	0.26	1.8	0.0096	0.067	0.014	0.013	0.0
748T	04-1579	F	N	74336	445	5.8	0.026	0.15	100	0.25	1.5	0.0093	0.056	0.013	0.012	0.0
763A	02-1585	M	Q	74346	408	9.9	0.024	0.24	101	0.22	2.2	0.0081	0.081	0.011	0.011	0.0
750A	01-1577	M	M	74330	428	10.5	0.022	0.23	102	0.18	1.8	0.0067	0.067	0.0092	0.0085	0.0
763S	02-1583	F	P	74344	406	8.2	0.033	0.27	103	0.15	1.2	0.0056	0.044	0.0078	0.0072	0.0
758C	01-1578	M	O	74331	401	7.7	0.021	0.17	104	0.15	1.1	0.0056	0.041	0.0077	0.0072	0.0
756A	02-1578	M	O	74331	402	10.2	0.024	0.24	105	0.12	1.3	0.0044	0.048	0.0065	0.0060	0.0
749T	04-1577	F	N	74330	430	7.9	0.027	0.21	106	0.12	0.94	0.0044	0.035	0.0062	0.0059	0.0

BETA RADIATION DOSE TO LUNG

DOSE RATE (GY/DAY)				CUMULATIVE DOSE (GY)							
) /S	120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENTIAL 5000 DAYS	TO DEATH	DEATH DATE	DAYS TO DEATH	COMMENT
)	0.51	0.33	0.11	39.	72.	170.	500. +	380.	74285	1461	D-HEMANGIOSARCOMA,HEART
)	0.34	0.20	0.035	27.	50.	110.	330. +	290.	76358	2313	E-HEMANGIOSARCOMA,HEART
)	0.33	0.23	0.035	26.	47.	110.	400. +	360.	78223	2753	E-HEMANGIOSARC.,RIB;B-A-CARCINOMA
)	0.41	0.32	0.049	28.	53.	140.	490. +	440.	76275	2429	D-HEMANGIOSARCOMA,HEART;B-A-CARCINOMA
)	0.38	0.27	0.016	26.	50.	130.	340. +	320.	77304	2596	D-PULMONARY INJURY;COMBINED CARC.,LUNG
)	0.34	0.23	0.029	25.	46.	110.	340. +	310.	77224	2496	E-SQUAMOUS CELL CARCINOMA,NASAL CAVITY
)	0.33	0.24	0.083	24.	45.	110.	410. +	310.	75072	1683	E-HEMANGIOSARCOMA,SITE UNDETERMINED
)	0.30	0.19	0.010	23.	42.	100.	290. +	280.	79234	3306	D-HEMANGIOSARCOMA,HEART
)	0.32	0.23	0.077	23.	43.	110.	400. +	310.	75217	1807	D-HEMANGIOSARCOMA,TBLN
)	0.33	0.23	0.030	23.	43.	110.	340. +	310.	77091	2615	D-ASPIRATION PNEUMONIA;B-A-CARCINOMA
)	0.30	0.22	0.093	22.	41.	100.	410. +	290.	79104	1593	D-HEMANGIOSARCOMA,HEART
)	0.31	0.25	0.083	21.	40.	110.	400. +	310.	76176	1703	D-HEMANGIOSARCOMA,HEART
)	0.28	0.20	0.043	20.	37.	95.	340. +	290.	77140	2305	E-HEMANGIOSARCOMA,HEART
)	0.26	0.18	0.027	19.	36.	87.	280. +	250.	77171	2443	D-HEMANGIOSARCOMA,HEART
)	0.25	0.17	0.0063	17.	33.	84.	220. +	210.	81014	3767	E-HEMANGIOSARCOMA,DISSEMINATED
)	0.23	0.16	0.043	17.	32.	80.	290. +	230.	80260	2104	E-HEMANGIOSARCOMA,LUNG
)	0.23	0.17	0.023	16.	3.0	79.	290. +	260.	77310	2830	D-SQ.CELL CARC,LUNG;HEMANGIOSARC.,TBLN
)	0.20	0.14	0.022	16.	29.	72.	230. +	220.	84163	3477	D-HEMANGIOSARCOMA,UNDET.;PUL. ADENOMA
)	0.22	0.17	0.059	15.	30.	78.	320. +	240.	80109	1963	E-HEMANGIOSARCOMA,MUSCLE
)	0.21	0.17	0.047	14.	27.	74.	300. +	240.	76295	2094	D-HEMANGIOSARCOMA,HEART
)	0.18	0.12	0.020	14.	25.	60.	200. +	180.	78329	2587	D-HEMANGIOSARCOMA,TBLN
)	0.16	0.10	0.0060	13.	23.	53.	150. +	140.	79158	3412	D-ULCERATIVE PHARYNGITIS
)	0.18	0.13	0.035	13.	24.	62.	230. +	190.	76201	2156	D-HEMANGIOSARCOMA,HEART
)	0.17	0.12	0.020	12.	23.	57.	200. +	170.	77223	2565	E-HEMANGIOSARCOMA,LUNG
)	0.16	0.12	0.038	12.	22.	55.	240. +	190.	77076	2241	E-HEMANGIOSARCOMA,HEART
)	0.17	0.12	0.013	12.	23.	57.	200. +	190.	79173	3245	E-HEMANGIOSARCOMA,HEART
)	0.17	0.12	0.020	12.	22.	56.	200. +	180.	77315	2636	E-HEMANGIOSARC.,SITE UNO.;B-A-CARCINOMA
)	0.14	0.11	0.029	10.	19.	48.	180. +	150.	80186	2030	E-HEMANGIOSARCOMA,SPLEEN
)	0.11	0.079	0.019	7.7	15.	37.	130. +	110.	81091	2301	E-HEMANGIOSARCOMA, LIVER
74	0.066	0.049	0.0070	4.8	9.0	23.	88. +	86.	86161	4200	E-HEMANGIOSARCOMA,TBLN
73	0.067	0.048	0.0090	4.6	8.8	23.	84. +	80.	85256	3929	E-HEMANGIOSARCOMA,TBLN
58	0.059	0.040	0.0070	4.4	8.2	20.	70. +	61.	84024	3332	E-ANGIOSARCOMA,TBLN
71	0.065	0.050	0.010	4.5	8.5	22.	90. +	85.	84272	3594	E-HEMANGIOSARCOMA,HEART
54	0.057	0.042	0.0060	4.2	7.8	20.	73. +	72.	89153	5296	D-PUL. FIBROSIS, PUL. ADENOCARCINOMA
58	0.053	0.039	0.0050	3.7	7.0	18.	66. +	64.	86234	4274	E-HEMANGIOSARCOMA,TBLN;CARCINOMA,LUNG
48	0.044	0.031	0.0077	3.1	5.8	15.	48. +	39.	80045	1905	E-HEMANGIOSARCOMA,TBLN
47	0.046	0.036	0.0040	3.0	5.8	16.	71. +	73.	88047	4824	E-MESOTHELIOMA, PLEURAL
44	0.041	0.032	0.0040	2.7	5.3	14.	55. +	49.	83213	3155	E-HEMANGIOSARCOMA,SPLEEN
38	0.035	0.028	0.0040	2.4	4.6	12.	45. +	44.	84314	3620	E-CARCINOMA,LUNG
39	0.036	0.028	0.0050	2.4	4.7	12.	52. +	48.	85345	4032	E-HEMANGIOSARCOMA,TBLN
29	0.026	0.019	0.0048	1.8	3.5	8.8	31. +	26.	80196	2057	E-HEMANGIOSARCOMA,TBLN
16	0.015	0.012	0.0012	0.99	1.9	5.2	23. +	22.	86365	4412	D-CARDIOMYOPATHY,HEART
15	0.013	0.0093	0.00080	0.93	1.8	4.5	17. +	16.	86199	4238	E-CARCINOMA,MAMMARY GLAND
14	0.013	0.010	0.0010	0.89	1.7	4.6	17. +	16.	86323	4774	E-CHOLANGIOCARCINOMA,LIVER
13	0.011	0.0069	0.00070	0.81	1.5	3.7	10. +	8.8	82188	2765	E-HEMANGIOSARCOMA,TBLN
13	0.012	0.0087	0.00060	0.79	1.5	4.0	11. +	10.	82351	2927	D-PULMONARY THROMBOSIS
12	0.011	0.0079	0.00030	0.76	1.5	3.8	9.7+	9.5	86143	4190	D-HEART FAILURE
11	0.0099	0.0075	0.00080	0.66	1.3	3.4	15. +	14.	88041	4808	E-HEMANGIOSARCOMA, SPLEEN
085	0.0079	0.0058	0.00080	0.53	1.0	2.7	11. +	9.5	85172	3860	E-LYMPHOSARCOMA,LIVER
072	0.0067	0.0048	0.00020	0.45	0.87	2.3	5.8+	5.7	87182	4591	E-LYMPHOSARCOMA,BRAIN
072	0.0068	0.0054	0.00070	0.45	0.87	2.4	7.9+	7.7	84093	3414	E-HEMANGIOSARCOMA,TBLN
060	0.0056	0.0040	0.00020	0.38	0.72	1.9	6.6+	6.2	88176	4958	E-PYELONEPHRITIS
059	0.0055	0.0042	0.00045	0.36	0.70	1.9	5.7+	5.5	82075	2667	E-HEMANGIOSARCOMA,LIVER

A.15 ^{90}Sr in Fused Aluminosilicate Particles, Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				I.B.B.		I.L.B.					DOSE RATE (G	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	MBQ/KG	MBQ	RANK	UCI/KG	UCI	MBQ/KG	MBQ	INITIAL	60 DAYS	120 DAYS
354S	02-699	F	B	70027	417	7.8			C							
361B	01-699	M	A	70027	408	12.0			C							
397U	01-788	F	D	70212	403	7.5			C							
399B	02-788	M	C	70212	382	10.9			C							
401S	01-811	F	F	70240	406	8.5			C							
402B	02-811	M	E	70240	399	11.1			C							
405W	01-816	F	G	70247	398	6.8			C							
413U	01-830	F	I	70289	413	9.4			C							
418C	02-830	M	H	70289	368	11.4			C							
431S	02-851	F	K	71025	417	7.4			C							
437A	01-851	M	J	71025	378	10.9			C							
497A	01-962	M	L	71299	374	11.1			C							
751S	03-1576	F	N	74329	420	11.6			C							
754C	01-1576	M	M	74329	402	6.7			C							
758A	02-1576	M	O	74329	399	11.2			C							
758B	03-1582	M	Q	74343	413	10.4			C							
761S	01-1582	F	R	74343	407	9.8			C							
762T	02-1582	F	P	74343	406	7.2			C							

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDED.

BETA RADIATION DOSE TO LUNG

DOSE RATE (GY/DAY)				CUMULATIVE DOSE (GY)					DEATH DATE	DAYS TO DEATH	COMMENT
60 DAYS	120 DAYS	365 DAYS	AT DEATH	60 DAYS	120 DAYS	365 DAYS	POTENTIAL 5000 DAYS	TO DEATH			
									81198	4189	E-ADENOCARCINOMA, MAMMARY GLAND
									83211	4932	D-CARCINOMA,LUNG
									85273	5540	E-PYELONEPHRITIS,KIDNEY
									84073	4974	E-ADENOCARCINOMA,PROSTATE
									85106	5345	E-ADENOCARCINOMA,MAMMARY GLAND
									85133	5372	D-BRONCHOPNEUMONIA,LUNG
									80275	3680	D-CARCINOMA,LUNG
									83244	4703	E-CARCINOMA,BLADDER
									85067	5257	E-MALIGNANT MELANOMA,ORAL
									82244	4237	E-TRANSITIONAL CELL CARCINOMA,BLADDER
									85318	5407	D-LYMPHOSARCOMA,GENERALIZED
									82140	3859	E-CARCINOMA,HEPATOCELLULAR
									86200	4254	D-FIBROMA,VAGINA
									86022	4076	D-HEMANGIOSARCOMA,HEART
									84211	3534	E-ADENOCARCINOMA,PANCREAS
									86335	4375	D-BRONCHIOLITIS,LUNG
									81344	2558	D-ACCIDENTAL DEATH
									91159	6025	D-PYELONEPHRITIS;CARCINOMA,LUNG

ARE INCLUDED.

A.16 ^{144}Ce in Fused Aluminosilicate Particles, Repeated Exposure Study

DOG IDENTIFICATION				INITIAL EXPOSURE			FINAL EXPOSURE			BETA RADIATION DOSE TO LUNG						
										DOSE RATE (GY/DAY)			CUMULATIVE DOSE (GY)			
TATTOO	AN-EXPT	SEX	GROUP	DATE	AGE DAYS	WT KG	DATE	AGE DAYS	WT KG	AFTER INITIAL EXP.	AFTER FINAL EXP.	AT DEATH	365 DAYS	730 DAYS	POTENT. INFIN.	TO DEATH
645C	01-1294	M	I	73340	518	8.3	75288	1195	9.5	.18	.75	.0028	130	370	520	520
648U	02-1294	F	I	73340	513	6.5	75288	1191	7.1	.18	.64		130	350	480	480
664C	03-1294	M	I	73340	452	9.6	75288	1130	11.7	.20	.65	.0038	130	370	500	500
641T	04-1294	F	I	73340	526	8.9	75288	1204	11.5	.19	.60	.0017	110	310	440	440
644T	05-1294	F	I	73340	518	7.1	75288	1195	8.3	.14	.64	.065	120	350	480+	460
646S	01-1295	F	I	73341	518	7.1	75289	1196	9.0	.15	.48		100	260	360	360
654T	02-1295	F	I	73341	495	7.6	75289	1173	8.5	.17	.72	.0011	130	350	500	500
645S	03-1295	F	I	73341	519	9.0	75289	1197	12.5	.24	.55	.00044	110	300	410	410
641C	04-1295	M	I	73341	527	9.3	75289	1205	11.3	.23	.71	.0012	150	380	520	520
662U	01-1292	F	II	73338	458	6.2	75286	1136	7.2	.58	.46		170	340	430	430
654B	02-1292	M	II	73338	492	6.3	75286	1170	7.2	.54	.54		160	340	450	450
645A	03-1292	M	II	73338	516	10.7	75286	1194	12.1	.74	.55	.00085	180	360	470	470
651S	04-1292	F	II	73338	500	8.4	75286	1178	9.4	.62	.57		170	360	470	470
665B	05-1292	M	II	73338	434	8.8	75286	1112	10.2	.67	.53	.00052	180	350	460	460
654A	01-1293	M	II	73339	493	10.6	75287	1171	11.6	.56	.53	.0022	180	380	490	490
641B	02-1293	M	II	73339	525	10.9	75287	1203	12.5	.55	.46	.00056	170	340	430	430
648B	03-1293	M	II	73339	512	8.6	75287	1220	9.0	.55	.58	.0054	170	370	480	480
648S	04-1293	F	II	73339	512	7.5	75287	1220	8.2	.66	.65	.020	190	390	520	520
649U	01-1290	F	III	73333	502	9.2	75282	1180	9.2	.30	.28	.0036	87	180	230	230
650U	02-1290	F	III	73333	501	8.5	75282	1178	10.0	.26	.32		91	200	260	260
649V	03-1290	F	III	73333	502	7.8	75282	1180	8.9	.33	.29	.00056	93	190	250	250
650B	04-1290	M	III	73333	501	9.8	75282	1178	11.3	.30	.34		93	200	270	270
641A	05-1290	M	III	73333	519	13.5	75282	1178	13.2	.34	.24	.00072	87	180	230	230
662S	01-1291	F	III	73334	454	10.8	75283	1133	11.5	.31	.19	.00019	85	210	250	250
655U	02-1291	F	III	73334	486	8.2	75283	1165	10.4	.28	.25	.0028	78	160	210	210
644S	03-1291	F	III	73334	512	10.5	75283	1191	11.6	.33	.23		84	170	210	210
665A	04-1291	M	III	73334	430	10.4	75283	1109	10.9	.39	.25	.17	94	190	240+	190
664B	01-1288	M	C	73331	443	11.3	75273	1115	11.8							
664A	02-1288	M	C	73331	443	11.9	75273	1115	11.9							
648T	03-1288	F	C	73331	504	7.9	75273	1076	8.9							
663S	04-1288	F	C	73331	451	9.5	75273	1123	11.2							
646B	05-1288	M	C	73331	508	8.2	75050	957	9.8							
648A	01-1289	M	C	73332	505	8.4	75274	1178	9.1							
649B	02-1289	M	C	73332	501	10.9	75274	1174	11.4							
662T	03-1289	F	C	73332	452	9.8	75274	1124	9.7							
657A	04-1289	M	C	73332	477	9.6	75274	1150	10.6							

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EXPOSURE GROUPS:
GROUP I - LUNG BURDEN INCREASED BY .093 MBQ (2.5 UCI) 144-CE/KG BODY WEIGHT EVERY 56 DAYS FOR 13 EXPOSURES.
GROUP II - LUNG BURDEN RE-ESTABLISHED AT .33 MBQ (9.0 UCI) 144-CE/KG BODY WEIGHT EVERY 56 DAYS FOR 13 EXPOSURES.
GROUP III - LUNG BURDEN RE-ESTABLISHED AT .17 MBQ (4.5 UCI) 144-CE/KG BODY WEIGHT EVERY 56 DAYS FOR 13 EXPOSURES.

UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
MBQ/KG REPRESENTS MEGABEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
+ INDICATES THE DOG DIED BEFORE IT RECEIVED ITS POTENTIAL INFINITE DOSE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLUD

TO LUNG

ULATIVE DOSE (GY)

730 DAYS	POTENT. INFIN.	TO DEATH	DEATH DATE	DAYS FROM FIRST INHALATION TO DEATH	COMMENT
370	520	520	79240	2091	D-MYELOMALACIA;HEMANGIOSARCOMA,LUNG
350	480	480	80275	2491	D-FIBRINOUS PNEUMONIA
370	500	500	79124	1975	D-HEMANGIOSARC.,SPLEEN;SQUAM.CELL CARC.,LUNG
310	440	440	79315	2166	D-PULMONARY INJURY
350	480+	460	77135	1256	D-PULMONARY INJURY
260	360	360	85117	4159	D-INTERSTITIAL PNEUMONIA
350	500	500	80094	2309	D-HEMANGIOSARCOMA,HEART
300	410	410	80263	2478	E-CARCINOMA,THYROID
380	520	520	80074	2289	D-CARCINOMA,LUNG
340	430	430	81254	2838	E-HEMANGIOSARCOMA,TBLN;CARCINOMA,LUNG
340	450	450	83019	3333	E-HEMANGIOSARCOMA,SPLEEN
360	470	470	80092	2310	D-CARCINOMA,LUNG
360	470	470	82292	3241	E-CARCINOMA,LUNG;HEMANGIOSARCOMA,TBLN
350	460	460	80211	2429	D-ADENOCARCINOMA,LUNG
380	490	490	79215	2067	D-PNEUMONITIS AND FIBROSIS;B-A-CARCINOMA
340	430	430	80151	2368	D-CARCINOMA,LUNG
370	480	480	79008	1860	D-PNEUM. AND FIBROSIS;B-A-CARC.;HEMANGIOSARC.,TBLN
390	520	520	78071	1558	D-HEMOLYTIC ANEMIA
180	230	230	78279	1772	E-PARVOVIRUS INFECTION
200	260	260	81202	2791	E-HEMANGIOSARCOMA,SPLEEN
190	250	250	80032	2255	E-TUMOR,BRAIN
200	270	270	84200	3884	E-COMBINED CARCINOMA,LUNG;CARCINOSARCOMA,LUNG
180	230	230	79292	2150	E-HEMANGIOSARCOMA,LIVER
210	250	250	80199	2421	D-HEMANGIOSARCOMA,TBLN
160	210	210	78312	1804	E-HEMANGIOSARCOMA,TBLN
170	210	210	83139	3457	D-RADIATION PNEUMONITIS AND PULMONARY FIBROSIS
190	240+	190	76010	771	D-BONE MARROW APLASIA
			83356	3677	E-THYROID CARCINOMA
			86004	4421	D-HEMANGIOSARCOMA,KIDNEY
			76288	1052	D-AUTOHEMOLYTIC ANEMIA
			88273	5420	D-CARCINOMA,LUNG
			75067	466	D-ACCIDENTAL DEATH AFTER NINTH EXPOSURE
			88133	5279	E-LYMPHOSARCOMA,LIVER
			83166	3486	D-TRANSITIONAL CELL CARCINOMA,BLADDER
			86209	4625	E-FIBROSARCOMA,ORAL CAVITY
			85249	4300	D-PROSTATITIS

13 EXPOSURES.
FOR 13 EXPOSURES.
FOR 13 EXPOSURES.

NT FINDINGS ARE INCLUDED.

A.17 $^{238}PuO_2$ Monodisperse Aerosol (1.5 μm AMAD), Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATIO DOSE TO DEATH (GY) FROM ILB (WBC)			FROM ILB
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	LUNG	LIVER	BONE	LUNG
701A	02-1444	M	C	74122	430	9.4	01	1.0	9.3	37.	340.	300	59.	20.	9.6	51.
857V	01-1742	F	J	75343	395	9.8	02	1.0	9.3	37.	340.	440	57.	15.	7.1	74.
746B	02-1548	M	G	74253	364	10.3	03	0.87	9.3	32.	340.	280	66.	8.9	4.2	52.
718U	01-1484	F	F	74169	406	7.5	04	0.87	6.1	32.	230.	280	48.	15.	7.4	54.
726A	02-1490	M	E	74171	378	11.5	05	0.80	9.3	30.	340.	260	62.	13.	6.1	47.
690S	02-1358	F	B	74029	400	8.0	06	0.80	6.1	30.	230.	210	46.	16.	7.5	41.
684A	01-1362	M	A	74031	417	10.5	07	0.55	5.8	20.	210.	190	33.	13.	6.1	28.
877C	02-1832	M	K	76078	414	13.1	08	0.52	6.7	19.	250.	440	32.	2.6	1.2	55.
747S	03-1552	F	H	74255	366	7.8	09	0.49	3.8	18.	140.	130	29.	11.	5.3	27.
726T	03-1484	F	F	74169	376	10.0	10	0.44	4.3	16.	160.	150	26.	11.	5.3	26.
746T	01-1552	F	H	74255	366	9.6	11	0.41	3.9	15.	140.	110	24.	8.2	4.0	19.
708T	02-1540	F	D	74120	406	7.3	12	0.39	2.8	14.	100.	160	23.	6.0	2.9	35.
745A	03-1548	M	G	74253	368	7.9	13	0.37	2.9	14.	110.	110	22.	9.0	4.4	22.
707T	03-1444	F	D	74122	412	8.6	14	0.33	2.8	12.	100.	93	20.	8.6	4.2	18.
723C	01-1490	M	E	74171	383	8.7	15	0.32	2.8	12.	100.	100	19.	7.5	3.7	22.
858B	02-1746	M	I	75345	395	10.6	16	0.30	3.1	11.	110.	140	17.	5.3	2.6	20.
737A	02-1552	M	G	74255	418	10.3	17	0.29	3.0	11.	110.	89	18.	7.7	3.7	14.
861S	02-1742	F	J	75343	380	8.0	18	0.29	2.3	11.	85.	130	17.	4.8	2.3	25.
877T	02-1828	F	L	76077	413	9.8	19	0.27	2.6	10.	96.	200	16.	6.0	3.0	31.
858T	02-1744	F	J	75344	394	9.5	20	0.27	2.5	10.	93.	24	16.	16.	7.6	4.3
705B	01-1444	M	C	74122	416	8.0	21	0.26	2.1	9.6	78.	67	16.	7.8	3.7	14.
880T	01-1828	F	L	76076	401	7.6	22	0.25	1.9	9.3	70.	120	15.	5.7	2.8	25.
693B	03-1362	M	A	74031	383	9.7	23	0.23	2.3	8.5	85.	85	14.	6.6	3.2	14.
862A	01-1746	M	I	75345	380	8.3	24	0.23	1.9	8.5	70.	96	14.	4.9	2.4	18.
860C	03-1746	M	I	75345	384	11.0	25	0.21	2.3	7.8	85.	120	13.	5.6	2.7	16.
725B	02-1492	M	E	74172	379	11.3	26	0.20	2.2	7.4	81.	96	12.	6.6	3.2	13.
699A	01-1440	M	C	74120	434	8.3	27	0.19	1.5	7.0	56.	81	11.	4.7	2.3	15.
685A	03-1358	M	A	74029	415	10.0	28	0.19	1.9	7.0	70.	70	12.	5.9	2.9	12.
692S	01-1358	F	B	74029	384	8.3	29	0.18	1.5	6.7	56.	52	11.	6.4	3.1	11.
691S	03-1360	F	B	74030	399	13.0	30	0.17	1.7	6.3	63.	63	8.1	4.9	2.4	8.6
715C	02-1484	M	E	74169	422	9.6	31	0.15	1.4	5.6	52.	100	9.0	5.1	2.4	18.
725T	02-1486	F	F	74170	377	11.2	32	0.15	1.7	5.6	63.	74	9.3	4.7	2.3	11.
876A	03-1828	M	K	76077	421	11.7	33	0.13	1.5	4.8	56.	100	7.7	2.8	1.4	13.
704U	03-1440	F	D	74120	415	8.8	34	0.12	1.1	4.4	41.	78	7.5	2.6	1.3	14.
875A	03-1832	M	K	76078	427	13.2	35	0.11	1.5	4.1	56.	85	6.9	2.9	1.4	8.7
745T	01-1554	F	H	74256	371	9.1	36	0.10	0.87	3.7	32.	44	9.7	8.0	4.0	7.7
746A	01-1550	M	G	74254	365	8.7	37	0.090	0.80	3.3	30.	41	5.7	4.2	2.0	7.8
875S	01-1832	F	L	76078	427	10.7	38	0.090	1.0	3.3	37.	85	5.7	2.5	1.2	12.
692U	02-1362	F	B	74031	386	6.3	39	0.090	0.53	3.3	20.	31	5.3	4.1	2.0	5.3
877B	03-1834	M	K	76079	415	11.4	40	0.090	1.0	3.3	37.	59	5.4	2.7	1.3	11.
718V	03-1490	F	F	74171	408	7.9	41	0.080	0.63	3.0	23.	41	4.9	3.4	1.6	7.8
879S	01-1830	F	L	76077	405	9.7	42	0.070	0.73	2.6	27.	48	4.6	1.8	0.90	8.1
685B	03-1364	M	A	74032	418	9.4	43	0.070	0.67	2.6	25.	33	4.5	3.3	1.6	4.9
738A	03-1550	M	G	74254	410	10.4	44	0.070	0.73	2.6	27.	31	4.4	2.1	1.3	4.5
860B	03-1744	M	I	75344	383	10.7	45	0.060	0.61	2.2	23.	31	3.6	2.7	1.3	5.3
708U	02-1446	F	D	74123	409	7.4	46	0.060	0.42	2.2	16.	30	3.6	3.8	1.8	8.0
744U	01-1548	F	H	74253	376	7.8	47	0.060	0.44	2.2	16.	23	3.5	1.8	0.90	7.9
857X	01-1748	F	J	75346	398	9.3	48	0.060	0.51	2.2	19.	41	3.2	2.4	1.1	7.3
874B	03-1830	M	K	76077	428	12.3	49	0.050	0.59	1.9	22.	37	3.0	2.0	1.0	5.0
704T	01-1446	F	D	74123	418	9.5	50	0.050	0.45	1.9	17.	26	2.9	1.8	0.90	3.2
705A	01-1442	M	C	74121	415	10.5	51	0.050	0.49	1.9	18.	37	2.9	2.2	1.0	5.3

ULATIVE ALPHA RADIATION

DOSE TO DEATH (GY)

B (WBC)		FROM ILB (REC.)			DEATH	DAYS TO	
VER	BONE	LUNG	LIVER	BONE	DATE	DEATH	COMMENT
.	9.6	51.	17.	8.3	78012	1351	E-OSTEOSARCOMA,HUMERUS
.	7.1	74.	19.	9.2	78344	1097	D-PNEUMONITIS AND PULMONARY FIBROSIS
.9	4.2	52.	7.1	3.4	76315	792	D-PNEUMONITIS AND PULMONARY FIBROSIS
.	7.4	54.	17.	8.3	77355	1282	E-OSTEOSARC.,LUMB. VERT.;CARCINOMA,LUNG
.	6.1	47.	9.6	4.7	77182	1107	E-PNEUM. AND PUL. FIBROS.;CARC.,LUNG(I)
.	7.5	41.	14.	6.8	77313	1380	E-OSTEOSARCOMA,THOR. AND LUM.VERT.
.	6.1	28.	11.	5.1	78073	1503	E-OSTEOSARC.,THOR.VERT.;SARC.,LUNG(I)
.6	1.2	55.	4.5	2.1	77248	536	D-PNEUMONITIS AND PULMONARY FIBROSIS
.	5.3	27.	10.	4.9	78275	1481	D-CARCINOMA,LUNG
.	5.3	26.	11.	5.3	79023	1680	E-OSTEOSARC.,THOR.;CARC,LUNG(I)
.2	4.0	19.	6.3	3.1	78171	1377	E-OSTEOSARCOMA,HUMERUS
.0	2.9	35.	9.2	4.4	77128	1104	D-IMM.HEM.ANEMIA;PNEUM. AND PUL. FIBROS.
.0	4.4	22.	9.0	4.4	79045	1618	E-OSTEOSARCOMA,FEMUR AND STERNUM
.6	4.2	18.	7.6	3.8	79039	1743	E-OSTEOSARCOMA,HUMERUS
.5	3.7	22.	8.5	4.2	78263	1553	E-OSTEOSARCOMA,ILIUM
.3	2.6	20.	5.9	2.9	79129	1245	E-OSTEOSARCOMA,SACRUM;CARCINOMA,LUNG(I)
.7	3.7	14.	5.9	2.9	79178	1749	E-OSTEOSARC.,HUM.,LUM.VERT. AND ISCHIUM
.8	2.3	25.	6.9	3.3	79047	1165	E-OSTEOSARCOMA,LUMBAR VERTEBRAE
.0	3.0	31.	12.	5.8	80133	1517	E-BONE TUMOR,T3
.	7.6	4.3	4.3	2.0	87016	4055	E-SARCOMA, SITE UNDETERMINED
.8	3.7	14.	6.7	3.2	79255	1959	E-OSTEOSARCOMA, THOR. VERT. AND HUMERUS
.7	2.8	25.	9.6	4.7	80129	1514	E-BONE TUMOR,T2
.6	3.2	14.	6.6	3.2	79038	1833	E-OSTEOSARCOMA,HUMERUS
.9	2.4	18.	6.4	3.1	79306	1422	D-OSTEOSARCOMA,C5,L2
.6	2.7	16.	7.1	3.5	80304	1785	E-OSTEOSARCOMA,HUMERUS
.6	3.2	13.	6.9	3.3	80276	2295	E-OSTEOSARCOMA,HUMERUS
.7	2.3	15.	6.6	3.2	79010	1716	D-OSTEOSARCOMA,SCAPULA
.9	2.9	12.	6.2	3.0	79281	2078	E-OSTEOSARCOMA,T5;CARCINOMA,LUNG
.4	3.1	11.	6.0	2.9	80254	2416	E-FIBROSARCOMA,LIVER
.9	2.4	8.6	5.2	2.5	81019	2546	E-OSTEOSARCOMA,TIBIA
.1	2.4	18.	10.	3.9	80324	2346	E-OSTEOSARCOMA,HUMERUS AND SKULL
.7	2.3	11.	5.5	2.7	80028	2049	E-BONE TUMOR,HUMERUS
.8	1.4	13.	4.6	2.3	80060	1444	E-BONE TUMOR,T12
.6	1.3	14.	4.8	2.3	78072	1413	E-DISC PROTRUS.;CARCINOMA,LUNG(I)
.9	1.4	8.7	3.7	1.8	80305	1688	E-OSTEOSARCOMA,VERT. T10
.0	4.0	7.7	6.4	3.2	84116	3512	E-OSTEOSARCOMA,ILIUM
.2	2.0	7.8	5.9	2.8	83098	3131	D-MAST CELL TUMOR
.5	1.2	12.	5.3	2.6	81016	1765	E-OSTEOSARCOMA,ILIUM
.1	2.0	5.3	4.1	2.2	83087	3343	E-OSTEOSARCOMA,LUMBAR VERT. L7
.7	1.3	11.	5.4	2.1	81302	2050	E-OSTEOSARCOMA,PELVIS
.4	1.6	7.8	6.2	3.1	82183	2934	E-OSTEOSARCOMA,SACRUM
.8	0.90	8.1	3.2	1.4	80204	1588	E-BONE TUMOR,T8
.3	1.6	4.9	3.6	1.7	82278	3168	E-OSTEOSARC., THOR.T2 AND LUMBAR VERT.L4
.1	1.3	4.5	3.4	1.6	82098	2766	E-OSTEOSARCOMA,VERTEBRAE,T12,L1
.7	1.3	5.3	3.9	1.8	84235	3178	E-FIBROSARC.,LIVER;SQUAM. CARC.,GINGIVA
.8	1.8	8.0	8.9	4.0	86043	4303	E-OSTEOSARCOMA,BONE;CARCINOMA,LUNG
.8	0.90	7.9	4.1	2.0	80184	2122	E-ULCERATIVE ILEITIS
.4	1.1	7.3	5.7	2.7	84289	3230	E-OSTEOSARCOMA,PARIETAL;CARCINOMA,LUNG
.0	1.0	5.0	3.5	1.7	84002	2847	E-OSTEOSARCOMA,HUMERUS
.8	0.90	3.2	2.0	0.9	81163	2597	D-ACCIDENTAL DEATH
.2	1.0	5.3	4.6	2.2	83010	3176	E-OSTEOSARCOMA,THOR. VERT. T11

A.17 $^{238}PuO_2$ Monodisperse Aerosol (1.5 μm AMAD), Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DOSE TO DEATH (GY) FROM ILB (WBC)			FROM ILB (REC.		
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	LUNG	LIVER	BONE	LUNG	LIVER	BO
694A	02-1360	M	A	74030	370	11.8	52	0.050	0.53	1.9	20.	41	2.8	2.3	1.1	5.3	5.0	2.
862T	03-1742	F	J	75343	378	6.8	53	0.040	0.28	1.5	10.	26	2.3	3.1	1.4	6.5	7.6	3.
746S	02-1554	F	H	74256	367	10.9	54	0.040	0.42	1.5	16.	32	2.5	2.1	1.1	4.9	4.6	2.
723A	01-1486	M	E	74170	382	11.2	55	0.030	0.39	1.1	14.	31	2.2	1.5	0.70	4.3	3.5	1.
694S	02-1364	F	B	74032	372	9.7	56	0.030	0.33	1.1	12.	32	2.2	2.8	1.3	5.7	7.3	3.
859D	03-1748	M	I	75346	387	10.7	57	0.030	0.27	1.1	10.	27	1.6	1.9	0.90	4.4	5.4	2.
872V	01-1834	F	L	76079	443	8.9	58	0.020	0.19	0.74	7.0	18	1.3	1.0	0.50	3.5	2.6	1.
726S	03-1492	F	F	74172	379	8.5	59	0.020	0.17	0.74	6.3	20	1.3	1.4	0.70	4.1	4.5	2.
858A	01-1744	M	I	75344	394	10.2	60	0.020	0.19	0.74	7.0		1.2	2.0	0.90			
703B	02-1442	M	C	74121	421	9.6	61	0.020	0.19	0.74	7.0	24	1.3	1.6	0.70	4.4	5.6	2.
684S	01-1360	F	B	74030	416	10.1	62	0.020	0.17	0.74	6.3	23	1.1	1.2	0.60	3.8	4.6	2.
724S	01-1492	F	F	74172	380	9.1	63	0.020	0.15	0.74	5.6	24	1.1	1.2	0.60	4.4	5.1	2.
877S	02-1830	F	L	76077	413	10.7	64	0.010	0.15	0.37	5.6	23	0.90	0.90	0.40	3.6	3.6	1.
725A	03-1486	M	E	74170	377	10.6	65	0.010	0.14	0.37	5.2	26	0.80	1.1	0.50	4.2	5.7	2.
685C	01-1364	M	A	74032	418	9.6	66	0.010	0.19	0.37	7.0	17	1.3	1.2	0.60	2.9	3.0	1.
860S	02-1748	F	J	75346	385	10.2	67	0.010	0.11	0.37	4.1	25	0.70	0.70	0.30	4.1	4.3	2.
747A	02-1550	M	G	74254	365	8.3	68	0.010	0.070	0.37	2.6	18	0.60	0.60	0.30	3.7	4.0	1.
701C	03-1446	M	C	74123	431	8.8	69	0.010	0.070	0.37	2.6	21	0.50	0.80	0.40	4.1	6.8	3.
708V	03-1442	F	D	74121	407	8.2	70	0.010	0.050	0.37	1.9	22	0.40	0.60	0.30	4.7	7.3	3.
744T	03-1554	F	H	74256	379	7.4	71	0.010	0.040	0.37	1.5		0.30	0.30	0.10			
875B	02-1834	M	K	76079	428	11.4	72	0.003	0.030	0.11	1.1	14	0.20	0.30	0.10	2.1	2.9	1.
689U	02-1378	F	B	74038	415	9.1	C											
694C	01-1378	M	A	74038	378	7.9	C											
704A	02-1432	M	C	74113	408	10.2	C											
705S	01-1432	F	D	74113	407	5.5	C											
721A	01-1488	M	E	74170	384	13.0	C											
725S	02-1488	F	F	74170	377	10.1	C											
738C	01-1556	M	G	74263	419	9.6	C											
745S	02-1556	F	H	74263	378	9.6	C											
859C	02-1754	M	I	75344	385	11.3	C											
860T	01-1754	F	J	75344	383	9.2	C											
874U	01-1835	F	L	76078	429	9.4	C											
876B	02-1835	M	K	76078	422	11.4	C											

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
KBQ/KG REPRESENTS KILOBEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDED
(I) SIGNIFIES AN INCIDENTAL FINDING WHICH WAS NOT IMMEDIATELY LIFE-THREATENING.
CAUTION: THE RECONSTRUCTED INITIAL LUNG BURDENS, DENOTED BY (R) AND (REC) IN THIS TABLE MAY BE TOO HIGH BECAUSE OF CURRENT
ANALYTICAL RADIOCHEMICAL PROBLEMS. THIS MAY LEAD TO CALCULATED ORGAN DOSES THAT ARE TOO HIGH. THIS PROBLEM IS ESP
IMPORTANT FOR DOGS IN THE LOWER EXPOSURE LEVELS.

TIVE ALPHA RADIATION

BE TO DEATH (GY)

MDC) BONE	FROM ILB (REC.) LUNG	LIVER	BONE	DEATH DATE	DAYS TO DEATH	COMMENT
1.1	5.3	5.0	2.2	83270	3527	D-UNDETERMINED
1.4	6.5	7.6	3.6	88218	4623	E-CHONDROSARC.,LIVER;OSTEOSARCOMA,SCAPULA
1.1	4.9	4.6	2.1	85043	3805	E-OSTEOSARCOMA,FEMUR;FIBROSARCOMA,LIVER
0.70	4.3	3.5	1.6	82260	3012	E-OSTEOSARCOMA,SCAPULA
1.3	5.7	7.3	3.3	87086	4802	E-LIVER HEPATOCELLULAR CARCINOMA
0.90	4.4	5.4	2.5	88358	4760	E-PYELONEPHRITIS
0.50	3.5	2.6	1.2	84276	3119	E-OSTEOSARCOMA,SACRUM;FIBROSARC.,LIVER
0.70	4.1	4.5	2.1	86168	4379	E-OSTEOSARCOMA,BONE;CARCINOMA,LUNG
0.90				91089	5589	E-MYELOPROLIFERATIVE DISEASE
0.70	4.4	5.6	2.5	87134	4761	E-FIBROSARCOMA,BONE
0.60	3.8	4.6	2.1	86183	4536	D-BRONCHOPNEUMONIA
0.60	4.4	5.1	2.3	86204	4415	E-CARCINOMA,LUNG
0.40	3.6	3.6	1.7	87054	3995	E-OSTEOSARCOMA,BONE
0.50	4.2	5.7	2.7	88099	5042	E-CARCINOMA,LIVER;CARCINOMA,LUNG
0.60	2.9	3.0	1.4	85130	4116	E-MELANOMA,MOUTH
0.30	4.1	4.3	2.0	87128	4164	E-OSTEOSARCOMA,BONE
0.30	3.7	4.0	1.8	86093	4222	D-CARCINOMA,INTESTINE
0.40	4.1	6.8	3.1	89338	5694	E-HEMANGIOSARCOMA, SUBCUTIS
0.30	4.7	7.3	3.4	89100	5458	E-DEGENERATIVE JOINT DISEASE;B.A. CARC.
0.10				84298	3694	E-MAST CELL TUMOR,MOUTH
0.10	2.1	2.9	1.4	90088	5123	E-CHRONIC NEPHRITIS
				87036	4746	E-CARCINOMA,LUNG
				90073	5879	E-ADENOMA, PITUITARY
				87254	4889	E-MAST CELL TUMOR DISSEMINATED
				77241	1224	E-MALABSORPTION SYNDROME
				76260	820	D-LEUCOENCEPHALOMALACIA
				87015	4593	D-CARCINOMA,BLADDER
				89329	5546	E-CHRONIC NEPHRITIS
				89038	5254	E-CHRONIC INTERSTITIAL NEPHRITIS
				87196	4235	E-CARCINOMA,LUNG
				87315	4354	E-ADENOMA,PITUITARY;BRONCHOPNEUMONIA,LUNG
				86241	3816	E-CIRRHOSIS,LIVER
				90080	5116	D-ANESTHETIC DEATH

RE.
MENT FINDINGS ARE INCLUDED.

DO HIGH BECAUSE OF CURRENT
HIGH. THIS PROBLEM IS ESPECIALLY

A.18 $^{238}PuO_2$ Monodisperse Aerosol (3.0 μm AMAD), Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DOSE TO DEATH (GY)				
					AGE	WT							FROM ILB (WBC)			FROM ILB	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	DAYS	KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	LUNG	LIVER	BONE	LUNG	LIV
667T	01-1306	F	B	73347	433	7.1	01	1.50	11.	56.	400.	310.	120.	28.	13.	92.	22.
710C	02-1460	M	E	74143	427	8.7	02	1.30	11.	48.	420.	360.	86.	9.6	4.8	70.	7.8
736A	02-1540	M	G	74249	414	10.1	03	0.93	9.3	34.	340.	380.	48.	17.	8.0	53.	18.
667S	03-1306	F	B	73347	431	10.3	04	0.93	9.3	34.	340.	280.	48.	21.	9.8	37.	16.
674B	03-1302	M	A	73345	403	9.4	05	0.80	7.3	30.	270.	220.	42.	21.	10.	35.	17.
866A	02-1814	M	K	76062	441	12.3	06	0.80	9.5	30.	350.	510.	41.	16.	7.6	58.	23.
696A	03-1428	M	C	74113	433	10.8	07	0.73	8.0	27.	300.	240.	40.	18.	8.7	31.	14.
849S	02-1720	F	J	75324	424	8.2	08	0.65	5.3	24.	200.	200.	34.	12.	5.3	33.	11.
731S	01-1540	F	H	74249	437	6.5	09	0.60	3.9	22.	140.	140.	32.	11.	5.1	32.	11.
711S	01-1456	F	F	74141	423	7.2	10	0.58	4.2	21.	160.	160.	31.	15.	6.9	31.	14.
703S	01-1436	F	D	74115	415	7.5	11	0.53	3.9	20.	140.	93.	28.	13.	6.3	17.	8.1
736S	03-1538	F	H	74247	412	7.9	12	0.52	4.1	19.	150.	300.	39.	7.3	3.5	74.	14.
696S	03-1436	F	D	74115	435	5.4	13	0.44	2.4	16.	89.	78.	24.	12.	5.5	21.	10.
682V	02-1302	F	B	73345	373	8.3	14	0.41	3.4	15.	130.	130.	22.	10.	4.9	21.	9.9
852B	01-1720	M	I	75324	409	10.3	15	0.41	4.1	15.	150.	160.	21.	11.	5.3	17.	8.8
716T	02-1456	F	F	74141	393	8.8	16	0.41	3.6	15.	130.	140.	22.	9.2	4.4	23.	9.7
674A	01-1302	M	A	73345	404	10.6	17	0.39	4.2	14.	160.	140.	21.	9.8	4.7	19.	8.7
680B	02-1306	M	A	73347	393	10.0	18	0.39	3.9	14.	140.	89.	22.	13.	6.5	13.	7.8
695A	01-1428	M	C	74113	442	12.4	19	0.38	4.7	14.	170.	130.	21.	12.	5.7	16.	9.3
865S	01-1814	F	L	76062	442	7.2	20	0.38	2.7	14.	100.	130.	20.	10.	4.8	30.	15.
697B	02-1436	M	C	74115	430	12.7	21	0.34	4.3	13.	160.	110.	18.	5.1	2.5	12.	3.5
708A	03-1456	M	E	74141	427	11.0	22	0.32	3.5	12.	130.	130.	17.	7.1	3.4	18.	7.3
867A	01-1818	M	K	76064	432	12.4	23	0.31	3.9	11.	140.	170.	17.	8.0	3.8	20.	9.2
846A	03-1720	M	I	75324	431	12.7	24	0.29	3.6	11.	130.	130.	15.	6.2	2.9	11.	4.6
715B	03-1460	M	E	74143	396	9.8	25	0.23	2.2	8.5	81.	89.	2.1	6.1	3.0	13.	6.4
730S	01-1542	F	H	74252	442	10.6	26	0.21	2.3	7.8	85.	85.	17.	6.9	3.3	18.	7.2
870V	03-1814	F	L	76062	426	11.7	27	0.21	2.5	7.8	93.	140.	12.	6.0	2.9	20.	11.
733A	04-1538	M	G	74247	431	9.9	28	0.18	1.8	6.7	67.	110.	9.5	3.3	1.6	16.	5.5
736E	02-1538	M	G	74247	412	9.4	29	0.17	1.9	6.3	70.	130.	11.	3.5	2.6	19.	6.0
846B	02-1716	M	I	75322	429	9.6	30	0.17	1.7	6.3	63.	70.	9.6	5.1	2.5	7.9	4.2
715A	02-1462	M	E	74144	397	8.8	31	0.17	1.5	6.3	56.	56.	9.5	5.8	2.9	8.8	5.4
678T	01-1304	F	B	73346	398	8.1	32	0.17	1.4	6.3	52.	48.	9.6	7.3	3.5	10.	7.8
848S	01-1722	F	J	75325	427	9.6	33	0.16	1.5	5.9	56.	28.	8.9	8.1	3.8	4.5	4.0
869T	03-1818	F	L	76064	431	7.5	34	0.13	1.0	4.8	37.	63.	7.2	4.1	2.0	13.	7.3
696D	01-1438	M	C	74116	436	6.7	35	0.13	0.93	4.8	34.	41.	7.8	6.0	2.9	9.2	7.5
714U	01-1460	F	F	74143	402	6.6	36	0.11	0.67	4.1	25.	41.	5.9	5.5	2.7	9.5	8.5
674C	02-1308	M	A	73348	407	10.1	37	0.090	1.0	3.3	37.	44.	5.7	5.5	2.6	6.8	6.8
680A	03-1308	M	A	73348	394	11.5	38	0.090	1.1	3.3	41.	44.	5.3	3.6	1.7	5.3	3.6
848T	01-1716	F	J	75322	424	7.7	39	0.090	0.73	3.3	27.	41.	5.4	4.8	2.3	8.1	7.1
865D	02-1818	M	K	76064	444	10.2	40	0.090	0.87	3.3	32.	52.	4.8	3.5	1.7	8.7	5.4
874A	02-1820	M	K	76065	416	13.3	41	0.070	1.0	2.6	37.	59.	4.7	3.2	1.6	9.2	7.1
702S	03-1434	F	D	74114	415	8.1	42	0.070	0.60	2.6	22.	37.	4.2	4.0	1.9	5.7	5.4
846C	03-1718	M	I	75323	431	9.2	43	0.070	0.73	2.6	27.	41.	4.5	4.5	1.8	6.8	6.2
711T	01-1458	F	F	74142	424	6.5	44	0.070	0.49	2.6	18.	35.	4.4	4.6	2.3	8.5	8.9
733S	02-1542	F	H	74252	436	8.8	45	0.070	0.67	2.6	25.	37.	4.4	4.9	2.3	6.6	6.9
854B	01-1718	M	I	75323	396	7.6	46	0.070	0.51	2.6	19.	33.	3.9	4.0	1.8	6.6	6.2
856T	03-1716	F	J	75322	378	5.8	47	0.070	0.40	2.6	15.	30.	3.9	4.0	1.8	8.0	7.5
869U	02-1816	F	L	76063	430	8.4	48	0.060	0.52	2.2	19.	37.	3.3	1.9	1.5	6.2	3.5
735C	04-1540	M	G	74249	424	10.5	49	0.060	0.58	2.2	21.	35.	3.2	3.6	1.7	5.2	5.6
732A	01-1538	M	G	74247	434	11.0	50	0.060	0.61	2.2	23.	48.	3.1	2.1	1.0	6.6	4.2
697A	03-1438	M	C	74116	431	10.4	51	0.050	0.55	1.9	20.	37.	3.1	3.8	1.7	5.6	6.0

(R)	CUMULATIVE ALPHA RADIATION DOSE TO DEATH (GY)								
	FROM ILB (WBC)			FROM ILB (REC.)			DEATH	DAYS TO	
Q	LUNG	LIVER	BONE	LUNG	LIVER	BONE	DATE	DEATH	COMMENT
.	120.	28.	13.	92.	22.	11.	77099	1213	D-PNEUMONITIS AND PULMONARY FIBROSIS
.	86.	9.6	4.8	70.	7.8	3.9	76044	631	E-PNEUMONITIS AND PULMONARY FIBROSIS
.	48.	17.	8.0	53.	18.	8.8	77334	1181	E-OSTEOSAR.,LUN. VERT.;CARCINOMA,LUNG
.	48.	21.	9.8	37.	16.	7.6	77318	1432	E-OSTEOSARC.,CERV. VERT.;CARC.,LUNG(I)
.	42.	21.	10.	35.	17.	8.3	78202	1683	D-PNEUM. AND PUL. FIBROS.;CARC.,LUNG(I)
.	41.	16.	7.6	58.	23.	11.	79285	1319	E-CARCINOMA,LUNG
.	40.	18.	8.7	31.	14.	6.7	78180	1528	E-OSTEOSARCOMA,HUMERUS AND PALATINE
.	34.	12.	5.3	33.	11.	5.1	79047	1184	E-OSTEOSARCOMA,THOR. VERT. AND SACRUM
.	32.	11.	5.1	32.	11.	5.1	77314	1161	E-OSTEOSARCOMA,TIBIA AND FEMUR
.	31.	15.	6.9	31.	14.	6.8	78223	1543	E-OSTEOSARCOMA,ILIUM
.	28.	13.	6.3	17.	8.1	3.9	78222	1568	E-OSTEOSARCOMA,LUMBAR VERTEBRAE
.	39.	7.3	3.5	74.	14.	6.7	77117	966	D-PNEUM. AND PUL. FIBROS.;CARC.,LUNG(I)
.	24.	12.	5.5	21.	10.	4.8	78264	1610	E-OSTEOSARCOMA,HUMERUS
.	22.	10.	4.9	21.	9.9	4.7	78069	1550	E-OSTEOSARCOMA,LUMBAR VERTEBRAE
.	21.	11.	5.3	17.	8.8	4.3	80205	1707	E-BONE TUMORS,T8 AND C7
.	22.	9.2	4.4	23.	9.7	4.7	78096	1416	E-OSTEOSARCOMA,ISCHIUM AND ILIUM
.	21.	9.8	4.7	19.	8.7	4.2	78075	1556	E-OSTEOSARC.,CERV.VERT.,SCAP.;CARC.,LUNG
.	22.	13.	6.5	13.	7.8	3.9	79299	2143	D-CARCINOMA,LUNG
.	21.	12.	5.7	16.	9.3	4.5	79205	1918	D-OSTEOSARCOMA,HUMERI
.	20.	10.	4.8	30.	15.	7.2	80273	1672	E-BONE TUMORS,L4,ILIUM,SCAP.;CARC.,LUNG
.	18.	5.1	2.5	12.	3.5	1.7	77144	1125	E-OSTEOSARCOMA,CERVICAL VERTEBRAE
.	17.	7.1	3.4	18.	7.3	3.5	78089	1409	E-OSTEOSARCOMA.THORACIC VERTEBRAE
.	17.	8.0	3.8	20.	9.2	4.4	80191	1588	E-BONE TUMORS,HUMERI
.	15.	6.2	2.9	11.	4.6	2.2	79235	1372	E-OSTEOSARCOMA,THORACIC VERTEBRAE
.	2.1	6.1	3.0	13.	6.4	3.1	79016	1699	E-OSTEOSARCOMA,HUMERUS
.	17.	6.9	3.3	18.	7.2	3.4	80038	1977	D-PNEUMONITIS
.	12.	6.0	2.9	20.	11.	5.0	80330	1729	E-OSTEOSARCOMA,FEMUR;CARCINOMA,LUNG
.	9.5	3.3	1.6	16.	5.5	2.7	77353	1202	E-OSTEOSARCOMA,SACRUM,STERNUM AND FEMUR
.	11.	3.5	2.6	19.	6.0	4.5	79101	1680	E-OSTEOSARCOMA,HUMERUS
.	9.6	5.1	2.5	7.9	4.2	2.0	80274	1778	E-BONE TUMORS,HUMERUS
.	9.5	5.8	2.9	8.8	5.4	2.7	80129	2176	E-BONE TUMOR,HUMERUS
.	9.6	7.3	3.5	10.	7.8	3.6	81161	2737	D-OSTEOSARC.,HUMERI,T6-T12;CARC.,LUNG
.	8.9	8.1	3.8	4.5	4.0	1.9	85123	3451	E-OSTEOSARCOMA,FEMUR;CARCINOMA,LUNG
.	7.2	4.1	2.0	13.	7.3	3.6	81210	1973	E-OSTEOSARCOMA,VERT. L2
.	7.8	6.0	2.9	9.2	7.5	3.6	82152	2958	E-OSTEOSARCOMA,FRONTAL BONE
.	5.9	5.5	2.7	9.5	8.5	4.1	84023	3532	E-OSTEOSARC.,SCAP.,HUMER.;B.A.CARC.,LUNG
.	5.7	5.5	2.6	6.8	6.8	3.1	84072	3741	E-OSTEOSARCOMA,HUMERUS
.	5.3	3.6	1.7	5.3	3.6	1.7	80177	2385	E-OSTEOSARCOMA,L6;CARCINOMA,LUNG
.	5.4	4.8	2.3	8.1	7.1	3.4	85022	3353	E-OSTEOSARCOMA,RIB
.	4.8	3.5	1.7	8.7	5.4	2.6	83131	2624	E-KIDNEY ATROPHY
.	4.7	3.2	1.6	9.2	7.1	3.4	83343	2835	E-OSTEOSARC.,VERT. L6;ADENOCARC.,LUNG
.	4.2	4.0	1.9	5.7	5.4	2.6	84074	3612	E-OSTEOSARCOMA,SCAPULA
.	4.5	4.5	1.8	6.8	6.2	3.0	85290	3620	D-MYOCARDIAL DEGENERATION,HEART
.	4.4	4.6	2.3	8.5	8.9	4.2	85166	4042	D-CARCINOMA,LUNG
.	4.4	4.9	2.3	6.6	6.9	3.3	85288	4054	E-CARCINOMA,LUNG
.	3.9	4.0	1.8	6.6	6.2	3.1	86136	3831	E-OSTEOSARCOMA,BONE
.	3.9	4.0	1.8	8.0	7.5	3.8	86108	3804	E-OSTEOSARCOMA,BONE
.	3.3	1.9	1.5	6.2	3.5	2.9	81138	1902	D-EPILEPSY
.	3.2	3.6	1.7	5.2	5.6	1.9	86100	4234	E-CARCINOMA,LUNG
.	3.1	2.1	1.0	6.6	4.2	2.0	81103	2413	E-OSTEOSARCOMA,VERT. L5 AND S1
.	3.1	3.8	1.7	5.6	6.0	3.1	86119	4386	E-DISC PROTRUSION;CARCINOMA,LUNG

A.18 $^{238}PuO_2$ Monodisperse Aerosol (3.0 μm AMAD), Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DOSE TO DEATH (GY)				
					AGE	WT							FROM ILB (WBC)			FROM ILB (REC	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	DAYS	KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	LUNG	LIVER	BONE	LUNG	LIVER
680T	03-1304	F	B	73346	392	6.7	52	0.050	0.31	1.9	11.	24.	2.7	2.8	1.4	3.6	4.3
705C	03-1458	M	E	74142	436	9.3	53	0.040	0.40	1.5	15.	26.	2.4	2.0	0.90	4.0	3.2
872S	01-1820	F	L	76065	429	11.3	54	0.040	0.46	1.5	17.	35.	2.3	2.1	1.0	4.7	4.2
697S	02-1434	F	D	74114	429	8.0	55	0.040	0.31	1.5	11.	21.	2.2	1.9	0.90	3.2	2.7
715S	01-1462	F	F	74144	397	7.2	56	0.040	0.26	1.5	9.6	27.	2.1	2.9	1.4	5.8	8.1
704S	02-1428	F	D	74113	408	9.5	57	0.040	0.34	1.5	13.	26.	2.1	1.9	0.90	4.0	3.8
857S	02-1722	F	J	75325	377	11.8	58	0.030	0.40	1.1	15.	21.	1.8	0.80	0.40	2.5	1.1
714S	03-1462	F	F	74144	403	8.4	59	0.030	0.25	1.1	9.3	21.	1.7	1.8	0.80	3.9	3.7
734S	03-1542	F	H	74252	435	9.8	60	0.030	0.26	1.1	9.6	23.	1.6	1.6	0.70	3.6	3.8
871B	01-1816	M	K	76063	427	12.1	61	0.020	0.26	0.74	9.6	28.	1.2	1.7	0.80	3.6	5.0
679B	01-1308	M	A	73348	396	9.2	62	0.020	0.18	0.74	6.7	25.	1.1	1.4	0.60	4.3	5.6
865B	03-1816	M	K	76063	443	12.4	63	0.020	0.22	0.74	8.1	27.	1.0	1.4	0.60	3.4	4.5
849C	02-1718	M	I	75323	424	9.9	64	0.020	0.17	0.74	6.3	17.	1.0	0.80	0.40	2.6	2.0
856S	03-1722	F	J	75325	381	8.9	65	0.020	0.15	0.74	5.6	15.	1.0	1.4	0.60	2.6	3.7
732B	04-1542	M	G	74252	439	11.2	66	0.020	0.19	0.74	7.0	20.	0.90	0.50	0.30	2.6	1.5
680S	02-1304	F	B	73346	392	7.9	67	0.020	0.13	0.74	4.8	21.	0.90	1.4	0.60	4.3	6.1
699S	02-1438	F	D	74116	430	9.1	68	0.020	0.14	0.74	5.2	24.	0.90	1.2	0.60	4.1	5.8
734T	03-1540	F	H	74249	432	9.4	69	0.010	0.13	0.37	4.8	20.	0.80	0.90	0.40	3.4	3.6
870T	03-1820	F	L	76065	429	9.2	70	0.010	0.11	0.37	4.1	9.3	0.70	0.50	0.20	1.5	1.0
697D	01-1434	M	C	74114	429	10.2	71	0.010	0.080	0.37	3.0	18.	0.50	0.50	0.20	2.8	3.0
708C	02-1458	M	E	74142	428	7.8	72	0.010	0.040	0.37	1.5	22.	0.30	0.60	0.20	4.5	8.9
679S	02-1309	F	B	73348	396	7.4	C										
681E	01-1309	M	A	73348	381	9.5	C										
696C	01-1430	M	C	74113	433	8.3	C										
702U	02-1430	F	D	74113	414	8.9	C										
710A	02-1472	M	E	74150	434	11.4	C										
718T	01-1472	F	F	74150	387	7.4	C										
736B	01-1536	M	G	74241	407	10.5	C										
733T	02-1536	F	H	74242	426	7.5	C										
848A	02-1724	M	I	75329	431	8.8	C										
857U	01-1724	F	J	75329	381	9.4	C										
870U	01-1823	F	L	76063	400	10.0	C										
871A	02-1823	M	K	76063	400	10.0	C										

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
KBQ/KG REPRESENTS KILOBEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED RESPECTIVELY. PROMINENT FINDINGS ARE INCLUD
(I) SIGNIFIES AN INCIDENTAL FINDING WHICH WAS NOT IMMEDIATELY LIFE-THREATENING.
CAUTION: THE RECONSTRUCTED INITIAL LUNG BURDENS, DENOTED BY (R) AND (REC) IN THIS TABLE MAY BE TOO HIGH BECAUSE OF CURRE
ANALYTICAL RADIOCHEMICAL PROBLEMS. THIS MAY LEAD TO CALCULATED ORGAN DOSES THAT ARE TOO HIGH. THIS PROBLEM IS E
IMPORTANT FOR DOGS IN THE LOWER EXPOSURE LEVELS.

WA RADIATION

ATH (GY)

FROM ILB (REC.) LUNG	LIVER	BONE	DEATH DATE	DAYS TO DEATH	COMMENT
3.6	4.3	1.9	85086	4123	E-OSTEOSARCOMA,SACRUM
4.0	3.2	1.5	82266	3046	D-LYMPHOSARCOMA,VISCERAL
4.7	4.2	2.0	85214	3437	E-CHONDROSARCOMA,SCAPULA
3.2	2.7	1.5	83049	3222	E-PANCREATITIS
5.8	8.1	3.8	87211	4815	E-OSTEOSARCOMA,BONE
4.0	3.8	1.8	84027	3566	E-UNDIFF. SARC.,RIB;NEUROFIBROSARC.,LIV.
2.5	1.1	0.5	80024	1525	D-EPILEPSY
3.9	3.7	1.9	85005	3879	E-OSTEOSARCOMA,VERTEBRA;CARCINOMA,LUNG
3.6	3.8	1.7	85065	3831	E-OSTEOSARCOMA,VERTEBRA
3.6	5.0	2.3	89040	4726	E-CHRONIC INTER. NEPHRITIS;AORT. THROMB.
4.3	5.6	2.4	85310	4345	E-OSTEOSARCOMA,BONE
3.4	4.5	2.0	88257	4577	E-ADENOCARCINOMA,RECTUM;NEPHROPATHY
2.6	2.0	1.0	84079	3043	E-MELANOMA,SKIN
2.6	3.7	1.7	88326	4749	E-CHONDRO. OSTEOSARC,MUM.;PAP. ADCA.,LUNG
2.6	1.5	0.7	80015	1954	D-GASTRIC FOREIGN BODY
4.3	6.1	2.9	87183	4950	E-CARCINOMA,MAMMARY;CARCINOMA,LUNG
4.1	5.8	2.7	87216	4848	D-PNEUMONIA
3.4	3.6	1.9	86346	4480	E-CARCINOMA,LUNG
1.5	1.0	0.5	83162	2654	D-PYOMETRA
2.8	3.0	1.4	85149	4053	D-THROMBOSIS,AORTA
4.5	8.9	3.9	90086	5788	E-ANKYLOSING SPONDYLOSIS;ADENOCARCINOMA, LUNG
			86127	4527	E-CARCINOMA,MAMMARY
			88280	5410	D-INTERVERT. DISC DISEASE;BRONCHOPNEUM.
			87100	4735	E-PYELONEPHRITIS
			89087	5453	E-CHOLANGIOHEPATITIS
			86335	4568	D-ACUTE NEPHROSIS
			88231	5194	E-CARCINOMA,MAMMARY GLAND
			87119	4626	D-PULMONARY EDEMA
			82223	2903	E-LYMPHOSARCOMA,SKIN
			87087	4141	D-HEMANGIOSARCOMA,HEART
			80030	1527	D-EPILEPSY
			85063	3288	D-PYOMETRA
			87187	4142	E-ADENOMA,PITUITARY

DINGS ARE INCLUDED.

BECAUSE OF CURRENT
HIS PROBLEM IS ESPECIALLY

A.19 $^{239}PuO_2$ Monodisperse Aerosol (0.75 μm AMAD), Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DOSE (GY) TO DEATH	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	REC. LUNG
1134C	01-2686	M	K	78325	385	8.9	01	0.20	1.8	7.4	67.	100		41
1142V	01-2730	F	L	79052	421	9.1	02	0.19	1.7	7.0	63.	63		29
1109B	01-2560	M	I	78165	367	10.6	03	0.18	1.9	6.7	70.	63		30
1136A	03-2690	M	K	78326	368	10.4	04	0.17	1.8	6.3	67.	63		31
992B	01-2106	M	C	77069	399	10.8	05	0.16	1.7	5.9	63.	67		24
1092S	01-2528	F	H	78144	411	9.5	06	0.16	1.5	5.9	56.	59		29
1027U	01-2236	F	F	77216	421	10.3	07	0.15	1.5	5.6	56.	31		21
1125S	01-2610	F	J	78248	374	8.2	08	0.15	1.2	5.6	44.	41		23
1122T	03-2612	F	J	78244	388	7.6	09	0.11	0.87	4.1	32.	33		22
1107A	03-2562	M	I	78166	375	12.4	10	0.10	1.2	3.7	44.	56		25
1028U	03-2238	F	F	77217	421	8.7	11	0.10	0.87	3.7	32.	17		14
1097E	01-2534	M	G	78150	396	8.9	12	0.10	0.87	3.7	32.		23.	
980T	03-2082	F	B	77035	410	9.7	13	0.096	0.93	3.6	34.	44		23
1006B	01-2148	M	E	77118	373	8.5	14	0.079	0.67	2.9	25.	30		21
1098C	03-2536	M	G	78151	391	8.6	15	0.073	0.63	2.7	23.	34		24
996U	02-2174	F	D	77140	446	7.1	16	0.073	0.52	2.7	19.	19		18
963E	02-1954	M	A	77007	439	11.5	17	0.063	0.73	2.3	27.		15.	
999S	01-2172	F	D	77139	423	8.2	18	0.062	0.51	2.3	19.	30		26
1005C	03-2150	M	E	77119	377	10.3	19	0.062	0.64	2.3	24.	37		22
1001T	01-2174	F	D	77140	409	10.6	20	0.059	0.63	2.2	23.	31		18
990C	02-2108	M	C	77070	410	9.3	21	0.055	0.51	2.0	19.	23		15
1023W	02-2238	F	F	77217	438	9.4	22	0.054	0.51	2.0	19.	18		13
1130B	02-2690	M	K	78326	403	10.5	23	0.051	0.54	1.9	20.		14.	
1145T	03-2732	F	L	79053	414	9.8	24	0.049	0.48	1.8	18.	24		17
990A	01-2108	M	C	77070	410	9.5	25	0.047	0.45	1.7	17.	81		47
1006A	01-2150	M	E	77119	374	8.5	26	0.046	0.39	1.7	14.	21		18
1096S	03-2532	F	H	78145	395	8.6	27	0.043	0.37	1.6	14.		12.	
1143T	02-2732	F	L	79053	418	8.9	28	0.042	0.37	1.6	14.		11.	
963F	01-1954	M	A	77007	439	11.4	29	0.041	0.47	1.5	17.	22		14
1097C	02-2536	M	G	78151	397	9.0	30	0.041	0.37	1.5	14.		9.9	
1134B	01-2690	M	K	78326	386	10.0	31	0.040	0.40	1.5	15.		11.	
1121S	02-2612	F	J	78244	401	8.5	32	0.039	0.33	1.4	12.	23		19
1100B	02-2562	M	I	78166	399	9.5	33	0.028	0.27	1.0	10.		8.0	
970D	01-1952	M	A	77006	424	10.4	34	0.026	0.27	0.96	10.		7.6	
1096U	02-2532	F	H	78145	395	8.2	35	0.024	0.20	0.89	7.4		7.0	
969A	03-1954	M	A	77007	426	10.1	36	0.023	0.23	0.85	8.5		6.8	
982T	02-2082	F	B	77035	404	9.9	37	0.021	0.21	0.78	7.8		6.2	
1111B	01-2562	M	I	78166	365	9.7	38	0.021	0.20	0.78	7.4		5.8	
1125T	01-2612	F	J	78244	370	8.1	39	0.021	0.17	0.78	6.3		6.0	
976T	01-2080	F	B	77034	431	10.3	40	0.019	0.20	0.70	7.4		6.0	
977S	01-2082	F	B	77035	430	7.4	41	0.018	0.13	0.67	4.8		5.4	
1005D	02-2150	M	E	77119	377	9.6	42	0.015	0.14	0.55	5.2		3.8	
1143S	01-2732	F	L	79053	418	11.0	43	0.014	0.15	0.52	5.6		4.0	
1094T	01-2532	F	H	78145	401	10.6	44	0.010	0.11	0.37	4.1		3.0	
1028S	01-2238	F	F	77217	421	9.4	45	0.010	0.090	0.37	3.3		2.9	
988C	03-2108	M	C	77070	425	9.3	46	0.010	0.090	0.37	3.3		2.8	
996T	03-2174	F	D	77140	446	8.8	47	0.0080	0.070	0.30	2.6		2.4	
1096A	01-2536	M	G	78151	401	10.8	48	0.0060	0.070	0.22	2.6		2.0	

ATION DOSE (GY)

TH REC. LUNG	DEATH DATE	DAYS TO 9-30 1993	DAYS TO DEATH	COMMENT
41	81120		891	E-PNEUMONITIS AND PULMONARY FIBROSIS
29	82137		1181	E-PNEUMONITIS AND PULMONARY FIBROSIS
30	82224		1520	D-RAD.PNEUM.;PUL.FIB.;PULMONARY CARC.
31	82332		1467	D-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
24	80009		1035	D-PNEUMONITIS
29	82054		1371	E-PNEUMONITIS AND PULMONARY FIBROSIS
21	85073		2779	E-MENINGIOMA,BRAIN;CARCINOMA,LUNG
23	82067		1280	E-PNEUMONITIS AND PULMONARY FIBROSIS
22	82308		1525	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
25	83097		1757	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
14	85037		2742	E-CARCINOMA AND FIBROSARCOMA,LUNG
	84240		2281	E-FIBROSARC.,MEDIAST.;B.A. CARC.,LUNG
23	81153		1579	E-PNEUM. AND PUL. FIBROS.;CARC.,LUNG
21	82253		1961	E-FIBROSARCOMA,MUSCLE;PUL.CARCINOMA
24	83356		2031	E-PNEUMONITIS;B.A. CARCINOMA,LUNG
18	84030		2446	E-BRONCHIOLOALVEOLAR CARCINOMA,LUNG
	82357		2176	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
26	85103		2886	D-BRONCHIOLOALVEOLAR CARCINOMA,LUNG
22	83013		2085	D-PULMONARY CARCINOMA;PUL. FIBROSIS
18	83030		2081	E-PULMONARY CARCINOMA;PUL. FIBROSIS
15	82251		2007	D-HEMORRHAGIC ENTERITIS
13	85036		2741	D-PNEUM. AND PUL. FIBROSIS;CARC., LUNG
	87132		3093	E-CARCINOMA,LUNG
17	86059		2563	E-CARCINOMA,LUNG
47	81327		1718	E-PNEUMONITIS AND PULMONARY FIBROSIS
18	86202		3370	D-CARCINOMA,LUNG
	86338		3115	E-CARCINOMA,LUNG
	87082		2951	D-CARCINOMA,LUNG
14	86022		3302	E-CARCINOMA,LUNG
	84303		2343	E-ADENOCARCINOMA,PANCREAS
	87133		3094	E-CARCINOMA,LUNG
19	86074		2752	E-CARCINOMA,LUNG
	87308		3429	E-CARCINOMA,LUNG
	87251		3897	E-CARCINOMA,LUNG
	88154		3661	E-CARCINOMA,LUNG
	88152		4162	E-CARCINOMA,LUNG
	87151		3768	D-CARCINOMA,LUNG
	87256		3375	E-CARCINOMA,LUNG
	88053		3461	D-HEMANGIOSARCOMA,KIDNEY
	89177		4526	D-EXUDATIVE PNEUMONIA,LUNG
	89270		4618	E-PAPILLARY ADENOCARCINOMA,LUNG
	88273		4171	E-CARCINOMA,LUNG
	90005		3970	E-ADENOCARCINOMA,MAMMARY GLAND
	88082		3589	D-CARCINOMA,LUNG
	88357		4157	D-PAPILLARY ADENOCARCINOMA,LUNG
	87044		3626	E-MALIGNANT MELANOMA,MOUTH
	89032		4275	E-PAPILLARY ADENOCARCINOMA,LUNG
	90256		4488	D-BRONCHIOLOALVEOLAR CARCINOMA,LUNG

A.19 $^{239}PuO_2$ Monodisperse Aerosol (0.75 μm AMAD), Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DOSE (GY) TO DEATH	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	REC. LUNG
961A	03-1956	M	A	77007	448	11.0	C							
980S	02-2084	F	B	77035	410	8.4	C							
992A	02-2116	M	C	77080	406	10.0	C							
1007C	02-2146	M	E	77117	371	9.5	C							
999U	02-2168	F	D	77130	414	10.3	C							
1022W	02-2240	F	F	77231	423	7.2	C							
1095T	01-2530	F	H	78145	400	10.6	C							
1098A	01-2535	M	G	78150	390	9.9	C							
1106A	01-2564	M	I	78165	382	9.8	C							
1121T	02-2614	F	J	78244	405	9.6	C							
1131D	01-2688	M	K	78325	392	6.8	C							
1146S	01-2733	F	L	79052	408	11.0	C							

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
KBQ/KG REPRESENTS KILOBEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDE
CAUTION: THE RECONSTRUCTED INITIAL LUNG BURDENS, DENOTED BY (R) AND (REC) IN THIS TABLE MAY BE TOO HIGH BECAUSE OF CURREN
ANALYTICAL RADIOCHEMICAL PROBLEMS. THIS MAY LEAD TO CALCULATED ORGAN DOSES THAT ARE TOO HIGH. THIS PROBLEM IS ES
IMPORTANT FOR DOGS IN THE LOWER EXPOSURE LEVELS.

ADIATION DOSE (GY)

DEATH		DAYS		
REC. LUNG	DEATH DATE	TO 9-30 1993	TO DEATH	COMMENT
	90243		4977	D-HYPERADRENOCORTICISM
	86357		3609	D-MAST CELL SARCOMA
		6037		
	82184		1893	D-EPILEPSY
	85214		3006	D-PERITONITIS
	90094		4611	E-PROLAPSE,INTERVERTEBRAL DISCS
	93218		5552	D-PNEUMONIA,LUNG
	89156		4024	E-PROSTATITIS,RENAL FAILURE
	91317		4899	E-NEPHROPATHY,KIDNEY
	87306		3349	D-THROMBOSIS,LUNG
	90317		4375	E-BRONCHOPNEUMONIA
	92009		4705	E-POLYARTERITIS

T FINDINGS ARE INCLUDED.
IGH BECAUSE OF CURRENT
N. THIS PROBLEM IS ESPECIALLY

A.20 $^{239}PuO_2$ Monodisperse Aerosol (1.5 μm AMAD), Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DO	
													TO 9-30-93	TO DEAT
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	WBC LUNG
1155S	03-2744	F	L	79067	390	7.7	01	1.0	8.0	37.	300.	270.		
1110U	02-2592	F	H	78208	410	6.7	02	1.0	6.7	37.	250.	190.		
1137S	02-2726	F	J	79047	448	10.2	03	0.91	9.3	34.	340.	470.		
1101S	01-2592	F	H	78208	438	10.1	04	0.86	8.7	32.	320.	96.		
964S	01-1962	F	B	77013	444	8.9	05	0.85	7.6	31.	280.	330.		
990U	01-2114	F	D	77076	416	8.5	06	0.79	6.7	29.	250.	210.		
1117B	02-2604	M	I	78215	393	9.9	07	0.78	7.7	29.	280.	270.		
972A	02-1972	M	A	77020	436	10.0	08	0.57	5.7	21.	210.	150.		
1097B	04-2514	M	G	78117	363	9.7	09	0.57	5.5	21.	200.	190.		
1155T	02-2744	F	L	79067	390	6.7	10	0.51	3.4	19.	130.	170.		
996A	01-2132	M	C	77111	417	10.6	11	0.48	5.1	18.	190.	170.		
1015B	01-2196	M	E	77160	394	8.9	12	0.46	4.1	17.	150.	180.		
1027A	03-2196	M	E	77160	365	10.9	13	0.45	4.9	17.	180.	160.		
1099B	03-2602	M	I	78214	451	10.5	14	0.44	4.6	16.	170.	190.		
1110B	01-2604	M	I	78215	417	7.7	15	0.44	3.4	16.	130.	140.		
995C	03-2132	M	C	77111	433	9.9	16	0.40	4.0	15.	150.	110.		
1096C	03-2514	M	G	78117	367	9.8	17	0.38	3.7	14.	140.	130.		
1141U	03-2724	F	J	79046	429	6.7	18	0.33	2.2	12.	81.	93.		
977B	03-1972	M	A	77020	415	11.6	19	0.31	3.6	11.	130.	130.		
1092B	02-2514	M	G	78116	384	9.9	20	0.30	3.0	11.	110.	130.		
1023X	01-2210	F	F	77174	395	8.5	21	0.29	2.5	11.	93.	96.		
994S	02-2114	F	D	77076	401	9.3	22	0.29	2.7	11.	100.	81.		
1099V	02-2590	F	H	78207	414	8.9	23	0.24	2.1	8.9	78.	59.		
997C	02-2132	M	C	77111	416	10.3	24	0.23	2.4	8.5	89.	81.		
1134D	03-2684	M	K	78321	381	10.5	25	0.19	2.0	7.0	74.	70.		
1141S	01-2726	F	J	79047	430	10.0	26	0.19	1.9	7.0	70.	190.		
1095S	03-2588	F	H	78206	462	10.1	27	0.19	1.9	7.0	70.			64.
1099T	02-2588	F	H	78206	443	8.5	28	0.19	1.6	7.0	59.		76.	
989T	03-2114	F	D	77076	425	6.7	29	0.19	1.3	7.0	48.			45.
1148U	01-2744	F	L	79067	414	6.7	30	0.19	1.3	7.0	48.			43.
965S	02-1962	F	B	77013	444	10.0	31	0.17	1.7	6.3	63.			44.
964T	03-1962	F	B	77013	444	7.7	32	0.17	1.3	6.3	48.	37.		
1009T	01-2208	F	F	77173	421	10.8	33	0.16	1.7	5.9	63.			39.
1023B	02-2196	M	E	77160	381	10.0	34	0.15	1.5	5.6	56.			37.
970A	01-1972	M	A	77020	438	10.3	35	0.15	1.5	5.6	56.			36.
976A	01-1970	M	A	77019	419	12.6	36	0.14	1.8	5.2	67.	44.		
1020T	02-2210	F	F	77174	399	9.2	37	0.14	1.3	5.2	48.	41.		
1160T	03-2742	F	L	79066	368	8.3	38	0.13	1.1	4.8	41.			29.
994T	03-2112	F	D	77075	400	8.8	39	0.13	1.1	4.8	41.			33.
995A	03-2130	M	C	77110	432	10.4	40	0.12	1.2	4.4	44.			35.
1008S	03-2210	F	F	77174	425	9.9	41	0.11	1.1	4.1	41.			31.
1120A	02-2602	M	I	78214	382	9.3	42	0.11	1.0	4.1	37.			25.
1112W	03-2590	F	H	78207	402	8.2	43	0.11	0.93	4.1	34.	63.		
1130A	03-2682	M	K	78320	397	10.5	44	0.10	1.1	3.7	41.	26.		
1130T	01-2696	F	J	78334	411	8.3	45	0.10	0.87	3.7	32.			25.
1139U	01-2724	F	J	79046	441	8.9	46	0.098	0.87	3.6	32.			24.
966T	03-1960	F	B	77012	439	10.3	47	0.097	1.0	3.6	37.			24.
1007A	01-2194	M	E	77159	413	9.4	48	0.071	0.67	2.6	25.			18.
1129A	02-2682	M	K	78320	398	8.8	49	0.069	0.61	2.6	23.			24.
1132C	01-2684	M	K	78321	394	11.3	50	0.065	0.73	2.4	27.	150.		
1099C	01-2602	M	I	78214	451	10.5	51	0.060	0.63	2.2	23.			14.
1153T	02-2742	F	L	79066	395	8.3	52	0.057	0.47	2.1	17.			19.
1129B	02-2684	M	K	78321	398	10.7	53	0.056	0.60	2.1	22.	100.		
999A	02-2130	M	C	77110	394	7.8	54	0.051	0.40	1.9	15.			19.

ATIVE ALPHA RADIATION DOSE (GY)

9-30-93	TO DEATH			DAYS		
MBC LUNG	MBC LUNG	REC. LUNG	DEATH DATE	TO 9-30 1993	TO DEATH	COMMENT
		40.	79277		210	D-PNEUMONITIS
		31.	79049		206	D-PNEUMONITIS
		60.	79296		249	D-PNEUMONITIS
		17.	79190		347	E-PNEUMONITIS
		63.	77349		336	D-PNEUMONITIS
		59.	78198		487	D-PNEUMONITIS
		32.	79071		221	D-PNEUMONITIS
		41.	78216		561	E-PNEUMONITIS
		28.	79030		278	E-PNEUMONITIS
		66.	80224		522	E-PNEUMONITIS
		45.	78339		593	E-PNEUMONITIS
		40.	78194		399	D-PNEUMONITIS
		56.	79282		852	D-PNEUMONITIS
		34.	79236		387	E-PNEUMONITIS
		36.	79262		412	D-PNEUMONITIS
		59.	80349		1333	D-PNEUM. AND PUL.FIBROSIS;CARC.,LUNG
		54.	80291		904	D-PNEUMONITIS AND PULMONARY FIBROSIS
		50.	81108		793	D-PNEUMONITIS
		27.	78158		503	D-PNEUMONITIS
		47.	80123		737	E-PNEUMONITIS
		35.	79096		652	E-PNEUMONITIS
		30.	79074		728	D-PNEUMONITIS
		27.	81058		947	E-PNEUMONITIS AND PULMONARY FIBROSIS
		40.	80282		1266	D-PNEUMONITIS AND PULMONARY FIBROSIS
		5.6	79108		152	E-PNEUMONITIS
		32.	80027		345	D-PNEUMONITIS
	64.		87123		3204	D-CARCINOMA,LUNG
76.				5546		
	45.		81299		1684	D-PNEUM.AND PUL.FIB.;PUL. CARCINOMA
	43.		83146		1540	E-PNEUMONITIS AND PULMONARY FIBROSIS
	44.		82168		1981	E-PNEUM.AND PUL.FIB.;PUL.CARCINOMA
		27.	80295		1377	E-PNEUMONITIS AND PULMONARY FIBROSIS
	39.		82277		1930	E-PUL. CARCINOMAS;PUL. FIBROSIS
	37.		82121		1787	D-PNEUM.AND PUL.FIB.;PUL.CARCINOMA
	36.		82003		1809	D-PUL.CARCINOMA;PNEUM.AND PUL.FIB.
		20.	80362		1438	D-PNEUM. AND PUL.FIBROSIS;CARC.,LUNG
		20.	80213		1134	D-PNEUMONITIS
	29.		83133		1528	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
	33.		82262		2013	D-PULMONARY CARCINOMA;PUL.FIBROSIS
	35.		84220		2666	E-BRONCHIOLOALVEOLAR CARCINOMA,LUNG
	31.		83252		2269	E-PUL.CARCINOMAS;PUL. FIBROSIS
	25.		83101		1713	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
		36.	81197		1086	E-PNEUMONITIS AND PULMONARY FIBROSIS
		11.	81197		973	D-CARC.,KIDNEY;PNEUM. AND PUL. FIB.
	25.		83287		1779	E-PNEUMONITIS;BRONCHIOLOALVEOLAR CARC.
	24.		83350		1765	E-PNEUMONITIS AND PULMONARY FIBROSIS
	24.		81353		1802	D-PNEUM.AND PUL.FIB.;PUL.CARCINOMA
	18.		82274		1941	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
	24.		87085		3052	E-CARCINOMA,LUNG
		43.	80296		705	D-PNEUMONITIS AND PULMONARY FIBROSIS
	14.		83123		1735	D-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
	19.		88145		3366	E-CARCINOMA,LUNG
		37.	81087		862	D-PNEUMONITIS AND PULMONARY FIBROSIS
	19.		88358		4265	E-MALIGNANT MELANOMA,ORAL

A.20 $^{239}PuO_2$ Monodisperse Aerosol (1.5 μm AMAD), Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DOSE TO 9-30-93	CUMULATIVE ALPHA RADIATION DOSE TO DEATH	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	WBC LUNG	REC. LUNG
1130C	01-2682	M	K	78320	397	9.0	55	0.048	0.43	1.8	16.			17.	
972S	02-1960	F	B	77012	428	8.2	56	0.046	0.38	1.7	14.			13.	
1022T	02-2208	F	F	77173	394	9.5	57	0.045	0.43	1.7	16.			16.	
992T	01-2112	F	D	77075	405	7.0	58	0.043	0.30	1.6	11.			14.	
1110S	01-2590	F	H	78207	409	9.0	59	0.040	0.36	1.5	13.			12.	
1025D	02-2194	M	E	77159	367	10.7	60	0.039	0.42	1.4	16.			11.	
1007B	03-2194	M	E	77159	413	11.3	61	0.035	0.40	1.3	15.			13.	
978B	02-1970	M	A	77019	406	8.6	62	0.028	0.24	1.0	8.9			10.	
1094B	01-2514	M	G	78116	372	12.3	63	0.027	0.33	1.0	12.			6.2	
1113A	03-2600	M	I	78213	408	9.5	64	0.026	0.25	0.96	9.3			9.8	
1017A	02-2192	M	E	77158	389	9.0	65	0.023	0.21	0.85	7.8			9.1	
1096D	02-2512	M	G	78116	366	10.5	66	0.021	0.22	0.78	8.1			6.0	
1134S	02-2694	F	J	78333	393	8.2	67	0.020	0.16	0.74	5.9			7.6	
970F	03-1970	M	A	77019	437	8.8	68	0.017	0.15	0.63	5.6			6.2	
992D	01-2130	M	C	77110	440	10.4	69	0.017	0.18	0.63	6.7			4.9	
1112U	01-2588	F	H	78206	401	9.1	70	0.016	0.15	0.59	5.6			6.5	
969U	02-1958	F	B	77012	431	9.7	71	0.015	0.15	0.55	5.6			5.5	
1146T	02-2724	F	J	79046	402	8.8	72	0.015	0.13	0.55	4.8			5.8	
1014C	01-2192	M	E	77158	397	8.5	73	0.014	0.12	0.52	4.4			5.5	
1010T	03-2208	F	F	77173	418	10.0	74	0.014	0.14	0.52	5.2	4.8			2.3
1153S	01-2742	F	L	79066	395	8.9	75	0.012	0.11	0.44	4.1			4.8	
1092C	01-2512	M	G	78116	382	9.7	76	0.011	0.11	0.41	4.1			4.1	
986S	02-2112	F	D	77075	431	8.1	77	0.011	0.087	0.41	3.2			3.9	
960U	01-1960	F	B	77012	446	9.1	78	0.010	0.093	0.37	3.4			3.9	
1110A	02-2600	M	I	78213	415	8.4	79	0.0095	0.080	0.35	3.0			3.6	
970S	01-1958	F	B	77012	430	9.6	80	0.0076	0.073	0.28	2.7			2.9	
988U	02-2110	F	D	77074	429	8.9	81	0.0070	0.062	0.26	2.3			2.8	
994B	02-2128	M	C	77109	434	10.0	82	0.0063	0.063	0.23	2.3			2.6	
1100A	01-2600	M	I	78213	446	9.6	83	0.0061	0.059	0.23	2.2			2.4	
1097A	02-2508	M	G	78115	361	9.0	84	0.0061	0.055	0.23	2.0			2.4	
1132D	02-2680	M	K	78319	392	9.7	85	0.0060	0.058	0.22	2.1		2.4		
1010W	02-2206	F	F	77172	417	10.4	86	0.0043	0.045	0.16	1.7		1.8		
1130S	01-2694	F	J	78333	410	8.3	87	0.0040	0.033	0.15	1.2			1.5	
972D	02-1968	M	A	77018	434	8.5	88	0.0040	0.034	0.15	1.3			1.6	
1154S	02-2740	F	L	79065	388	9.0	89	0.0034	0.031	0.13	1.1			1.4	
1149T	01-2740	F	L	79065	411	7.5	90	0.0033	0.025	0.12	0.92			1.3	
971C	01-1968	M	A	77018	435	8.2	91	0.0024	0.020	0.089	0.74			0.98	
1131B	01-2680	M	K	78319	395	11.0	92	0.0023	0.025	0.085	0.92			0.90	
988S	01-2110	F	D	77074	429	9.5	93	0.0022	0.021	0.081	0.78			0.81	
997A	01-2128	M	C	77109	414	10.6	94	0.0018	0.019	0.067	0.70			0.70	
1095A	01-2508	M	G	78115	371	11.2	95	0.0013	0.015	0.048	0.55			0.51	
1022V	01-2206	F	F	77172	393	9.6	96	0.0007	0.007	0.026	0.26			0.29	
960T	02-1956	F	B	77007	441	9.4	C								
977A	01-1974	M	A	77024	415	11.7	C								
982S	03-2116	F	D	77080	446	10.0	C								
998A	01-2146	M	C	77117	416	10.5	C								
1010A	01-2198	M	E	77160	405	12.4	C								
1021S	01-2212	F	F	77174	396	9.3	C								
1093B	01-2510	M	G	78115	375	7.9	C								
1107S	01-2594	F	H	78208	417	9.0	C								
1109A	01-2605	M	I	78215	417	11.8	C								
1131A	01-2681	M	K	78319	395	12.2	C								
1136S	01-2695	F	J	78333	375	9.0	C								
1152S	01-2746	F	L	79065	396	9.2	C								

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
KBQ/KG REPRESENTS KILOBEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDE
CAUTION: THE RECONSTRUCTED INITIAL LUNG BURDENS, DENOTED BY (R) AND (REC) IN THIS TABLE MAY BE TOO HIGH BECAUSE OF CURREN
ANALYTICAL RADIOCHEMICAL PROBLEMS. THIS MAY LEAD TO CALCULATED ORGAN DOSES THAT ARE TOO HIGH. THIS PROBLEM IS ES
IMPORTANT FOR DOGS IN THE LOWER EXPOSURE LEVELS.

A RADIATION DOSE (GY)

TO DEATH			DAYS		
WBC LUNG	REC. LUNG	DEATH DATE	TO 9-30 1995	TO DEATH	COMMENT
17.		88301		3633	E-PAPILLARY ADENOCARCINOMA,LUNG
13.		82334		2148	D-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
16.		87056		3535	E-CARCINOMA,LUNG
14.		85221		3068	E-PNEUMONITIS AND PULMONARY FIBROSIS
12.		85030		2380	D-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
11.		84017		2414	E-ADENOCARCINOMA,LUNG
13.		87285		3778	E-CARCINOMA,LUNG
10.		88021		4019	E-CARCINOMA,LUNG
6.2		82302		1647	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
9.8		90059		4229	E-PAPILLARY ADENOCARCINOMA,LUNG
9.1		90270		4860	E-OSTEOSARCOMA,STERNUM
6.0		84265		2340	E-MULTIPLE CARCINOMAS,LUNG
7.6		91317		4732	D-KIDNEY INFARCTION
6.2		87312		3945	D-PNEUMONITIS, FIBROUS ADENOMA,LUNG;
4.9		83234		2315	D-JEJUNUM, SMOOTH MUSCLE TUMOR
6.5		92150		5057	E-CARCINOMA,LUNG
5.5		86358		3633	E-HEMOLYTIC ANEMIA
5.8		92321		5023	D-CARCINOMA,LUNG
5.5		90115		4705	E-TRANSITIONAL CELL CARCINOMA,BLADDER
	2.3	80187		1109	D-NECROTIC PHARYNGITIS
4.8		92163		4845	E-CARCINOMA,LUNG
4.1		89033		3935	E-PAPILLARY ADENOCARCINOMA,LUNG
3.9		87206		3783	D-CARCINOMA,LUNG
3.9		89041		4412	E-ADENOCARCINOMA,OSTEOSARCOMA,LUNG
3.6		90120		4290	E-LYMPHOSARCOMA
2.9		89159		4530	E-PAPILLARY ADENOCARC.,MAM. GLAND
2.8		92079		5483	E-CARCINOMA,THYROID
2.6		92363		5732	D-CARCINOMA,LUNG
2.4		91306		4841	D-NECROSIS,ADRENAL
2.4		91010		4643	E-CARCINOMA,LUNG
			5433		
			5945		
1.5		91015		4430	D-PLEUROPNEUMONIA
1.6		91214		5309	D-CARCINOMA,LUNG;CARCINOMA,LARYNX
1.4		92333		5016	D-PHEOCHROMOCYTOMA,ADRENAL
1.3		92107		4790	D-MYOPATHY,HEART
0.98		92084		5544	E-NEPHROPATNY,KIDNEY; ADENOMA,LUNG
0.90		93043		5203	D-THROMBOSIS,LUNG
0.81		88012		3955	D-TRANSITIONAL CARCINOMA,BLADDER
0.70		90262		4901	E-RENAL CELL CARCINOMA,KIDNEY
0.51		90248		4516	E-HEPATOCELLULAR CARCINOMA,LIVER
0.29		91027		4968	D-CARCINOMA,MAMMARY GLAND
		91322		5428	E-CARCINOMA,MAMMARY GLAND
		88349		4342	E-CHRONIC INTERSTITIAL NEPHRITIS
		89200		4503	E-MALIGNANT MELANOMA,ORAL
		92234		5595	E-CARCINOMA,LUNG
		91263		5216	E-ASTROCYTOMA
		91331		5270	E-CARCINOMA,LIVER
		90173		4441	D-RENAL AMYLOIDOSIS
		92330		5235	E-CARCINOMA,MAMMARY GLAND
			5537		
		88139		3472	E-OSTEOSARCOMA,BONE
		92013		4793	E-NECROSIS,LIVER
		93203		5252	E-CARCINOMA,MAMMARY GLAND

DINGS ARE INCLUDED.
BECAUSE OF CURRENT
HIS PROBLEM IS ESPECIALLY

A.21 $^{239}PuO_2$ Monodisperse Aerosol (3.0 μm AMAD), Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)						ILB (R)	CUMULATIVE ALPHA RADIATION D TO DEATH	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	REC LUN
1122B	03-2620	M	K	78251	395	8.5	01	2.0	17.	74.	620.	540		38
984A	02-2104	M	C	77068	426	11.3	02	1.4	15.	52.	570.	480		28
1069A	03-2398	M	G	78018	431	11.6	03	1.4	16.	52.	590.	490		63
1004S	03-2170	F	D	77133	395	8.9	04	1.3	11.	48.	420.	390		53
1152V	03-2738	F	L	79061	392	9.7	05	1.2	12.	44.	440.	330		71
981T	03-2078	F	B	77033	403	11.1	06	1.1	13.	41.	470.	420		51
1138T	03-2722	F	J	79039	440	6.7	07	0.88	5.9	33.	220.	110		48
997D	03-2144	M	E	77117	422	8.4	08	0.77	6.5	28.	240.	240		76
1001A	02-2144	M	E	77117	389	10.4	09	0.70	7.3	26.	270.	110		31
1100D	03-2554	M	I	78159	392	10.7	10	0.68	7.3	25.	270.	250		54
1069B	02-2398	M	G	78018	431	11.3	11	0.58	6.5	21.	240.	220		68
1117D	02-2620	M	K	78251	429	9.2	12	0.58	5.3	21.	200.	280		79
1034S	03-2234	F	F	77215	401	7.7	13	0.56	4.3	21.	160.	220		69
1099A	02-2554	M	I	78159	396	11.2	14	0.56	6.3	21.	230.	93		38
1124B	01-2620	M	K	78251	382	11.2	15	0.56	6.3	21.	230.	240		49
1101U	03-2552	F	H	78158	388	10.5	16	0.55	5.8	20.	210.	200		64
977T	02-2078	F	B	77033	428	7.9	17	0.52	4.1	19.	150.	100		35
980A	01-2104	M	C	77068	443	10.5	18	0.51	5.4	19.	200.	200		59
977U	01-2078	F	B	77033	428	10.5	19	0.47	4.9	17.	180.	140		40
1149S	02-2738	F	L	79061	407	8.8	20	0.42	3.7	16.	140.		85.	
964A	01-1950	M	A	77005	436	9.9	21	0.39	3.9	14.	140.	160		53
1137U	02-2722	F	J	79039	440	10.4	22	0.36	3.7	13.	140.	160		65
1000B	01-2144	M	E	77117	459	10.9	23	0.35	3.8	13.	140.	190		86
1105T	02-2552	F	H	78158	377	10.1	24	0.35	3.5	13.	130.	100		45
1007S	01-2170	F	D	77133	387	7.5	25	0.33	2.5	12.	93.	78		36
1071A	01-2398	M	G	78018	427	10.4	26	0.30	3.1	11.	110.		62.	
1029S	01-2234	F	F	77215	417	10.5	27	0.28	2.9	10.	110.	93		30
989A	03-2104	M	C	77068	417	9.9	28	0.28	2.8	10.	100.		62.	
980V	01-2076	F	B	77032	407	9.0	29	0.27	2.4	10.	89.	81		32
1105A	01-2554	M	I	78159	378	10.3	30	0.25	2.6	9.3	96.	100		43
1101T	01-2552	F	H	78158	388	8.4	31	0.25	2.1	9.3	78.	74		39
1137T	01-2722	F	J	79039	440	10.0	32	0.24	2.4	8.9	89.		50.	
1147U	01-2738	F	L	79061	409	9.3	33	0.24	2.2	8.9	81.		45.	
1005S	02-2170	F	D	77133	391	8.8	34	0.24	2.1	8.9	78.		59.	
1117C	03-2618	M	K	78250	428	11.0	35	0.16	1.8	5.9	67.		42.	
1070A	03-2396	M	G	78017	427	10.5	36	0.16	1.7	5.9	63.		37.	
1023U	02-2234	F	F	77215	436	7.9	37	0.14	1.1	5.2	41.		36.	
1008T	01-2166	F	D	77132	383	7.9	38	0.12	0.93	4.4	34.		38.	
963A	02-1950	M	A	77005	437	12.1	39	0.12	1.4	4.4	52.		27.	
1152U	03-2736	F	L	79060	391	9.4	40	0.11	1.0	4.1	37.		33.	
1139T	03-2720	F	J	79038	433	9.8	41	0.11	1.1	4.1	41.		25.	
1104A	02-2556	M	I	78160	381	11.0	42	0.11	1.2	4.1	44.		29.	
1005B	03-2142	M	E	77118	376	8.9	43	0.10	0.93	3.7	34.		39.	
1097D	03-2556	M	I	78160	406	9.9	44	0.10	1.0	3.7	37.		23.	
1070B	02-2396	M	G	78017	427	11.5	45	0.096	1.1	3.6	41.		32.	
1121B	02-2618	M	K	78250	407	9.2	46	0.087	0.80	3.2	30.		26.	
1023V	03-2232	F	F	77214	435	8.7	47	0.084	0.73	3.1	27.		25.	
986A	01-2102	M	C	77067	423	10.8	48	0.074	0.80	2.7	30.		22.	
1106S	03-2550	F	H	78157	374	10.2	49	0.072	0.73	2.7	27.		21.	
999B	02-2142	M	E	77116	400	9.2	50	0.062	0.57	2.3	21.		23.	

ALPHA RADIATION DOSE (GY)

TO DEATH

BC MG	REC. LUNG	DEATH DATE	DAYS TO DEATH	COMMENT
	38	78356	105	E-PNEUMONITIS
	28	77184	116	D-PNEUMONITIS
	63	78306	288	D-PNEUMONITIS
	53	77363	230	D-PNEUMONITIS
	71	80123	427	E-PNEUMONITIS
	51	77289	256	D-PNEUMONITIS
	48	80305	631	E-PNEUMONITIS AND PULMONARY FIBROSIS
	76	78306	554	D-PNEUMONITIS
	31	79023	636	E-PNEUMONITIS
	54	79265	471	D-PNEUMONITIS
	68	80042	754	D-PNEUMONITIS
	79	80046	525	E-PNEUMONITIS
	69	78356	506	D-PNEUMONITIS
	38	81161	1098	E-PNEUMONITIS AND PULMONARY FIBROSIS
	49	79340	454	E-PNEUMONITIS
	64	80155	727	E-PNEUMONITIS
	35	78257	589	E-PNEUMONITIS
	59	79004	666	D-PNEUMONITIS
	40	78286	618	E-PNEUMONITIS
		82320	1355	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
	53	78342	702	E-PNEUMONITIS
	65	81313	1005	E-PNEUMONITIS AND PULMONARY FIBROSIS
	86	80130	1108	E-CARCINOMA,LUNG
	45	81077	1015	E-PNEUMONITIS AND PULMONARY FIBROSIS
	36	79184	781	D-PNEUMONITIS
		81356	1434	E-PULMONARY FIBROSIS;PUL.CARCINOMA
	30	79218	733	D-PNEUMONITIS
		81132	1525	E-PNEUM. AND PUL. FIBROSIS;CARC.,LUNG
	32	79178	876	D-PNEUMONITIS
	43	81118	1055	E-PNEUMONITIS AND PULMONARY FIBROSIS
	39	81105	1043	E-PNEUMONITIS AND PULMONARY FIBROSIS
		82365	1422	D-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
		82222	1257	E-PNEUMONITIS AND PULMONARY FIBROSIS
		82151	1844	D-PNEUM.AND PUL.FIB.;PUL.CARCINOMA
		83349	1925	E-ADENOCARCINOMA,LUNG
		82204	1648	E-PNEUM.AND PUL.FIB.;PUL.CARCINOMA
		83011	1987	E-PULMONARY FIBROSIS;PUL. CARCINOMA
		85110	2900	D-PNEUM. AND PUL. FIBROSIS;CARC.,LUNG
		81180	1636	D-PNEUM. AND PUL. FIBROSIS;CARC.,LUNG
		86301	2798	E-CARCINOMA,LUNG
		83138	1561	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
		84065	2096	E-BRONCHIOLOALVEOLAR CARCINOMA
		86328	3497	E-CARCINOMA,LUNG
		82357	1658	E-PNEUMONITIS AND PULMONARY FIBROSIS
		86280	3185	E-CARCINOMA,LUNG
		85143	2450	E-CARCINOMA,LUNG
		84109	2451	E-ADENOCARCINOMA,LUNG
		84038	2527	E-B.A. COMBINED CARCINOMAS,LUNG
		84353	2387	E-CARCINOMA,LUNG
		88228	4129	E-MALIGNANT MIXED TUMOR,LUNG

B

A.21 $^{239}PuO_2$ Monodisperse Aerosol (3.0 μm AMAD), Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DOSE (GY) TO DEATH	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	REC. LUNG
966A	02-1948	M	A	77004	431	11.1	51	0.058	0.64	2.1	24.		13.	
1160V	02-2736	F	L	79060	365	9.8	52	0.054	0.53	2.0	20.		17.	
1160S	01-2736	F	L	79060	365	9.3	53	0.053	0.49	2.0	18.		18.	
980U	03-2076	F	B	77032	408	11.9	54	0.040	0.47	1.5	17.		13.	
1139S	02-2720	F	J	79038	433	10.6	55	0.038	0.40	1.4	15.		15.	
988B	03-2102	M	C	77067	422	12.5	56	0.038	0.47	1.4	17.		13.	
981S	02-2076	F	B	77032	403	10.2	57	0.038	0.39	1.4	14.		15.	
1072B	01-2396	M	G	78017	425	11.4	58	0.034	0.39	1.3	14.		12.	
1101A	01-2556	M	I	78160	390	10.6	59	0.030	0.32	1.1	12.		10.	
1005U	03-2166	F	D	77132	390	9.3	60	0.029	0.27	1.1	10.		9.2	
1099S	02-2550	F	H	78157	394	7.8	61	0.029	0.23	1.1	8.5		8.6	
965A	03-1950	M	A	77005	436	12.3	62	0.029	0.36	1.1	13.		11.	
1121C	01-2618	M	K	78250	401	10.4	63	0.026	0.27	0.96	10.		9.5	
960A	03-1948	M	A	77004	438	10.0	64	0.025	0.25	0.92	9.3		9.0	
1034T	01-2232	F	F	77214	400	6.4	65	0.023	0.15	0.85	5.6		8.8	
1096T	01-2550	F	H	78157	407	9.8	66	0.019	0.19	0.70	7.0		7.6	
982A	02-2102	M	C	77067	437	10.5	67	0.018	0.19	0.67	7.0		6.7	
1138S	01-2720	F	J	79038	439	7.6	68	0.014	0.11	0.52	4.1		5.6	
994D	01-2142	M	E	77116	441	10.9	69	0.012	0.13	0.44	4.8		4.8	
963B	01-1948	M	A	77004	436	11.9	70	0.011	0.13	0.41	4.8		4.3	
1009S	02-2166	F	D	77132	380	10.6	71	0.010	0.11	0.37	4.1		3.7	
1033U	02-2232	F	F	77214	403	8.5	72	0.0060	0.053	0.22	2.0		2.4	
961D	01-1956	M	A	77007	448	11.6	C							
975S	01-2084	F	B	77035	433	7.4	C							
988D	01-2116	M	C	77080	435	10.0	C							
994C	03-2146	M	E	77117	442	12.7	C							
999T	01-2168	F	D	77130	414	8.4	C							
1033S	01-2240	F	F	77231	419	9.6	C							
1072C	01-2400	M	G	78019	427	10.5	C							
1104T	01-2558	F	H	78157	378	7.0	C							
1100C	01-2559	M	I	78158	391	10.6	C							
1122C	01-2622	M	K	78251	395	9.7	C							
1128U	01-2547	F	J	78352	407	8.7	C							
1152T	01-2739	F	L	79060	391	10.0	C							

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
KBQ/KG REPRESENTS KILOBEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDED.
CAUTION: THE RECONSTRUCTED INITIAL LUNG BURDENS, DENOTED BY (R) AND (REC) IN THIS TABLE MAY BE TOO HIGH BECAUSE OF CURRENT ANALYTICAL RADIOCHEMICAL PROBLEMS. THIS MAY LEAD TO CALCULATED ORGAN DOSES THAT ARE TOO HIGH. THIS PROBLEM IS ESPEC IMPORTANT FOR DOGS IN THE LOWER EXPOSURE LEVELS.

A RADIATION DOSE (GY)

TO DEATH

REC. LUNG	DEATH DATE	DAYS TO DEATH	COMMENT
	81121	1578	E-PNEUM. AND PUL. FIBROSIS;CARC.,LUNG
	87093	2955	D-CARCINOMA,LUNG
	88063	3290	E-CARCINOMA,LUNG
	84347	2871	E-SQUAMOUS CELL CARCINOMA,MOUTH
	93004	5080	D-CARCINOMA,LUNG
	87041	3626	E-CARCINOMA,LUNG
	89110	4461	E-ADENOSQUAMOUS CARCINOMA,LUNG
	87084	3354	E-CARCINOMA,LUNG
	87194	3321	E-CARCINOMA,LUNG
	85030	2820	E-CARCINOMA,LUNG
	85029	2429	D-CARCINOMA,LUNG
	90046	4789	E-PAPILLARY ADENOCARCINOMA,LUNG
	89194	3962	E-PAPILLARY ADENOCARCINOMA,LUNG
	87118	3766	E-CARCINOMA,LUNG
	89186	4355	E-HEMANGIOSARCOMA,LIVER; CARC.,LUNG
	92096	5052	D-CARCINOMA,PITUITARY
	88195	4145	E-CARCINOMA,LUNG
	91052	4397	E-CONGESTIVE HEART FAILURE
	89143	4410	E-PAPILLARY ADENOCARCINOMA,LUNG
	91118	5227	D-CONGESTIVE HEART FAILURE;CARCINOMA,LUNG
	87140	3660	E-CARCINOMA,LUNG
	90002	4536	D-ADENOCARCINOMA,PANCREAS
	89097	4473	E-SQUAMOUS CELL CARCINOMA,TONSIL
	89219	4567	E-TRANSITIONAL CELL CARCINOMA,BLADDER
	92211	5609	D-ULCERATIVE INFLAMMATION,JEJUNUM
	89321	4587	E-NEPHROBLASTOMA,KIDNEY
	90353	4971	D-MELANOMA,EYE
	92344	5591	E-CARCINOMA,LUNG
	83143	1950	D-CONGESTIVE HEART FAILURE
	93221	5543	E-CARCINOMA,MAMMARY GLAND
	93001	5322	D-CARDIOMYOPATHY,HEART
	91290	4787	E-CARCINOMA,LUNG
	88181	3481	E-OSTEOARTHRITIS,BONE
	92265	4953	E-CARCINOMA,LUNG

NDINGS ARE INCLUDED.
BECAUSE OF CURRENT
THIS PROBLEM IS ESPECIALLY

A.22 $^{239}PuO_2$ Monodisperse Aerosol (1.5 μm AMAD), Immature Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATIO	
													TO 9-30-93	TO D
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	WBC LUNG
1350A	01-3204	M	E	81296	104	2.4	01	0.79	1.9	29.	70.	21.		
1380V	03-3408	F	L	82266	96	3.9	02	0.74	2.9	27.	110.	130.		
1379A	01-3408	M	I	82266	96	4.8	03	0.69	3.3	26.	120.	56.		
1331S	02-3122	F	D	81225	97	2.8	04	0.64	1.8	24.	67.	12.		
1379T	02-3408	F	J	82266	96	4.7	05	0.57	2.7	21.	100.	84.		
1389A	01-3454	M	K	83060	80	3.9	06	0.54	2.1	20.	78.	33.		
1367S	01-3314	F	H	82091	89	3.3	07	0.55	1.8	20.	67.	30.		
1366C	01-3312	M	G	82090	89	3.1	08	0.55	1.7	20.	63.	63.		
1331A	01-3122	M	C	81225	97	4.1	09	0.51	2.1	19.	78.	34.		
1340T	01-3140	F	F	81246	84	2.9	10	0.32	0.90	12.	33.		25.	
1377T	03-3398	F	J	82244	100	3.6	11	0.28	0.99	10.	37.	27.		
1365S	01-3310	F	H	82089	90	3.5	12	0.28	0.96	10.	36.	26.		
1351S	01-3216	F	F	81321	95	2.6	13	0.28	0.74	10.	27.	23.		
1362A	01-3300	M	G	82082	99	4.5	14	0.27	0.12	10.	4.4		3.5	
1350C	02-3204	M	E	81296	104	2.5	15	0.24	0.59	8.9	22.	14.		
1217S	02-2856	F	B	79228	101	3.9	16	0.22	0.86	8.1	32.	41.		
1331U	01-3124	F	D	81226	98	2.8	17	0.21	0.60	7.8	22.			19.
1390S	02-3454	F	L	83060	80	3.1	18	0.21	0.66	7.8	24.			18.
1378B	04-3398	M	I	82244	97	4.4	19	0.19	0.83	7.0	31.	24.		
1337T	01-3130	F	D	81238	88	3.3	20	0.17	0.56	6.3	21.			18.
1336D	03-3130	M	E	81238	88	3.6	21	0.17	0.60	6.3	22.		19.	
1215A	01-2842	M	A	79220	100	5.2	22	0.16	0.82	5.9	30.	32.		
1366A	02-3310	M	G	82089	88	3.9	23	0.16	0.61	5.9	23.			15.
1337U	02-3130	F	F	81238	88	3.0	24	0.16	0.46	5.9	17.			17.
1220B	02-2844	M	A	79221	84	2.4	25	0.16	0.39	5.9	14.			10.
1364S	01-3304	F	H	82084	99	4.5	26	0.13	0.59	4.8	22.			14.
1387B	01-3442	M	K	82351	88	3.9	27	0.13	0.51	4.8	19.			12.
1365A	02-3304	M	G	82084	85	3.7	28	0.13	0.49	4.8	18.			11.
1377S	01-3390	F	J	82224	80	3.3	29	0.12	0.38	4.4	14.			9.4
1377A	02-3390	M	I	82224	80	3.4	30	0.10	0.35	3.7	13.			8.2
1384B	01-3418	M	K	82287	83	3.5	31	0.094	0.33	3.5	12.			8.7
1384S	02-3418	F	L	82287	83	2.8	32	0.089	0.25	3.3	9.3			6.6
1222T	02-2852	F	B	79227	79	1.9	33	0.079	0.15	2.9	5.6	16.		
1376A	01-3386	M	I	82223	87	2.2	34	0.074	0.16	2.7	5.9		5.8	
1339A	01-3132	M	E	81239	82	3.6	35	0.072	0.26	2.7	9.6		6.3	
1324T	01-3098	F	D	81174	98	5.3	36	0.069	0.39	2.6	14.			9.5
1376T	02-3386	F	J	82223	87	2.2	37	0.068	0.15	2.5	5.6		6.3	
1363S	02-3302	F	H	82083	100	3.3	38	0.067	0.22	2.5	8.1			7.1
1220T	01-2856	F	B	79228	91	2.5	39	0.065	0.16	2.4	5.9			5.4
1364A	01-3302	M	G	82083	98	3.9	40	0.056	0.22	2.1	8.1			6.3
1334D	02-3126	M	E	81231	95	2.2	41	0.056	0.12	2.1	4.4		3.6	
1222S	03-2852	F	B	79227	79	1.6	42	0.054	0.083	2.0	3.1			2.9
1217A	01-2844	M	A	79221	94	4.8	43	0.052	0.25	1.9	9.3			6.1
1387A	02-3442	M	K	82351	88	4.5	44	0.053	0.24	2.0	8.9			5.2
1387S	03-3442	F	L	82351	88	3.0	45	0.047	0.14	1.7	5.2		4.3	
1384A	02-3416	M	K	82286	82	3.7	46	0.043	0.16	1.6	5.9		4.6	
1382S	01-3416	F	L	82286	92	4.1	47	0.039	0.16	1.4	5.9			4.9
1338T	02-3132	F	F	81239	84	2.5	48	0.039	0.095	1.4	3.5		3.4	
1334B	01-3126	M	C	81231	95	3.1	49	0.035	0.11	1.3	4.1		2.7	
1367B	01-3320	M	I	82097	95	4.7	50	0.030	0.14	1.1	5.2		3.5	
1368T	02-3320	F	J	82097	88	2.7	51	0.026	0.070	0.96	2.6			2.2
1215B	03-2842	M	A	79220	100	4.6	52	0.024	0.11	0.89	4.1	11.		
1331C	02-3124	M	C	81226	98	4.0	53	0.024	0.093	0.89	3.4	12.		
1341S	02-3140	F	F	81246	84	2.6	54	0.024	0.062	0.89	2.3		2.4	

CUMULATIVE ALPHA RADIATION DOSE (GY)						
TO 9-30-93	TO DEATH			DAYS		
WBC LUNG	WBC LUNG	REC. LUNG	DEATH DATE	TO 9-30 1993	TO DEATH	COMMENT
		12.	87014		1909	E-CARCINOMA,LUNG
		84.	88012		1937	E-CARCINOMA,LUNG
		24.	87103		1663	D-CARCINOMA,LUNG
		0.62	81271		46	D-PARVOVIRUS INFECTION
		36.	86311		1506	E-CARCINOMA,LUNG
		18.	86316		1352	D-CARCINOMA,LUNG
		16.	86210		1580	E-CARCINOMA,LUNG
		36.	86051		1422	D-PNEUMONITIS; CARCINOMA,LUNG
		16.	86010		1611	D-PNEUMONITIS; CARCINOMA,LUNG
25.				4410		
		15.	86169		1386	E-PNEUMONITIS; CARCINOMA,LUNG
		15.	87210		1947	E-CARCINOMA,LUNG
		15.	87055		1925	E-CARCINOMA,LUNG
3.5				4209		
		8.6	86322		1852	E-ACCIDENTAL DEATH
		22.	84102		1700	E-RAD. PNEUM.;B.A. CARCINOMA,LUNG
	19.		88166		2496	E-CARCINOMA,LUNG
	18.		92027		3254	E-CARCINOMA,LUNG
		7.0	84253		739	D-HEMORRHAGIC ENTERITIS
	18.		92276		4055	E-CARCINOMA,LUNG
19.				4418		
		17.	85354		2326	E-CARCINOMA,LUNG
	15.		89249		2717	E-PULMONARY CARCINOMA,MULTIPLE
	17.		91235		3649	E-CARCINOMA,LUNG
	10.		87316		3017	E-CARCINOMA,LUNG
	14.		87239		1981	E-CARCINOMA,LUNG
	12.		89088		2294	E-ADENOSQUAMOUS CARCINOMA,LUNG
	11.		88200		2307	E-CARCINOMA,LUNG
	9.4		88251		2218	D-PNEUMONITIS/FIBROSIS; CARC.,LUNG
	8.2		92007		3435	E-CARCINOMA,LUNG
	8.7		93113		3844	E-CARCINOMA,LUNG
	6.6		88286		2190	E-ASTROCYTOMA,BRAIN
		10.	87078		2773	E-CARCINOMA,LUNG
5.8				4068		
6.3				4417		
	9.5		91036		3514	E-CARCINOMA,LUNG
6.3				4068		
	7.1		92289		3858	E-CARCINOMA,LUNG
	5.4		87301		2995	E-CARCINOMA,LUNG
	6.3		92043		3612	E-CARCINOMA,LUNG
3.6				4425		
	2.9		92194		4715	D-ACUTE DILATION,STOMACH
	6.1		91023		4185	D-CARCINOMA,LUNG
	5.2		90058		2629	E-ADENOCARCINOMA, LUNG
4.3				3940		
4.6				4005		
	4.9		92093		3459	E-CARCINOMA,LUNG
3.4				4417		
2.7				4425		
3.5				4194		
	2.2		90277		3102	D-CONGESTIVE HEART FAILURE
		4.9	83317		1558	D-HEMORRHAGIC ENTERITIS
		4.2	83246		750	D-HEMOLYTIC ANEMIA
2.4				4410		

A.22 $^{239}PuO_2$ Monodisperse Aerosol (1.5 μm AMAD), Immature Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DO		
													TO 9-30-93	TO DEATH	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	WBC LUNG	RE LU
1220D	02-2842	M	A	79220	83	2.2	55	0.023	0.050	0.85	1.9			1.5	
1320S	01-3068	F	D	81128	90	3.8	56	0.021	0.080	0.78	3.0			2.5	
1320A	01-3066	M	C	81127	89	4.6	57	0.020	0.093	0.74	3.4	43.			23
1320C	02-3066	M	C	81127	89	4.1	58	0.020	0.080	0.74	3.0			1.7	
1220S	02-2848	F	B	79226	89	3.4	59	0.018	0.059	0.67	2.2			1.9	
1362S	02-3300	F	H	82082	99	3.8	60	0.017	0.063	0.63	2.3		2.0		
1381B	03-3414	M	K	82288	99	5.3	61	0.015	0.078	0.55	2.9		1.9		
1381T	04-3414	F	L	82288	99	4.4	62	0.015	0.065	0.55	2.4		1.7		
1373U	03-3384	F	J	82222	100	4.0	63	0.014	0.054	0.52	2.0			1.5	
1374A	02-3384	M	I	82222	94	3.0	64	0.014	0.043	0.52	1.6		1.1		
1340A	01-3138	M	E	81245	83	3.8	65	0.013	0.049	0.48	1.8		1.2		
1221T	01-2864	F	B	79234	95	1.8	66	0.013	0.023	0.48	0.85			0.88	
1373T	01-3384	F	H	82222	100	4.2	67	0.012	0.051	0.44	1.9		1.5		
1335A	01-3128	M	C	81232	83	3.4	68	0.0094	0.032	0.35	1.2		0.83		
1318B	01-3054	M	C	81100	96	3.5	69	0.0064	0.022	0.24	0.81		0.60		
1352C	01-3222	M	G	81338	97	4.0	70	0.0063	0.025	0.23	0.92		0.62		
1340S	02-3138	F	F	81245	83	2.6	71	0.0058	0.015	0.21	0.55			0.46	
1221C	03-2840	M	A	79219	80	2.4	72	0.0054	0.013	0.20	0.48	5.2			2
1334S	03-3126	F	F	81231	92	3.7	73	0.0049	0.018	0.18	0.67		0.66		
1377B	01-3398	M	I	82244	100	4.4	74	0.0045	0.020	0.17	0.74		0.52		
1357S	02-3228	F	H	82008	96	3.2	75	0.0034	0.011	0.13	0.41			0.12	
1378S	02-3398	F	J	82244	97	4.2	76	0.0029	0.012	0.11	0.44			0.31	
1386A	01-3432	M	K	82323	94	4.3	77	0.0026	0.011	0.096	0.41		0.30		
1386S	02-3432	F	L	82323	94	3.5	78	0.0025	0.0088	0.093	0.33		0.32		
1357B	01-3228	M	G	82008	96	4.4	79	0.0025	0.011	0.093	0.41		0.32		
1342A	01-3160	M	E	81265	97	3.3	80	0.0021	0.0070	0.078	0.26		0.21		
1223S	03-2848	F	B	79226	78	2.7	81	0.0021	0.0057	0.078	0.21		0.14		
1217C	02-2840	M	A	79219	92	4.4	82	0.0012	0.0051	0.044	0.19			0.14	
1214B	01-2840	M	A	79219	100	6.0	83	0.00095	0.0057	0.035	0.21			0.11	
1335T	02-3128	F	D	81232	83	2.9	84	0.00093	0.0027	0.034	0.10		0.079		
1381S	02-3414	F	L	82288	99	3.9	85	0.00082	0.0032	0.030	0.12		0.088		
1381A	01-3414	M	K	82288	99	5.7	86	0.00060	0.0034	0.022	0.13		0.077		
1339B	01-3134	M	E	81243	86	3.0	87	0.00058	0.0017	0.021	0.063		0.046		
1317U	02-3052	F	D	81099	99	3.6	88	0.00056	0.0020	0.021	0.074			0.058	
1319S	03-3052	F	D	81009	94	4.1	89	0.00054	0.0022	0.020	0.081			0.063	
1355A	01-3224	M	G	81356	91	5.0	90	0.00040	0.0020	0.015	0.074		0.048		
1317A	01-3052	M	C	81099	98	3.9	91	0.00036	0.0014	0.013	0.052			0.030	
1367A	01-3316	M	I	82092	90	4.8	92	0.00035	0.0017	0.013	0.063			0.038	
1355T	02-3224	F	H	81356	91	4.1	93	0.00032	0.0013	0.012	0.048		0.032		
1338S	02-3134	F	F	81243	88	2.8	94	0.00031	0.00085	0.011	0.031			0.026	
1217T	01-2848	F	B	79226	99	5.0	95	0.00030	0.0015	0.011	0.056			0.051	
1368S	02-3316	F	J	82092	83	3.0	96	0.00025	0.00076	0.0093	0.028		0.024		
1216B	02-2857	M	A	79228	108	5.2	C								
1223T	01-2875	F	B	79240	92	2.8	C								
1317S	01-3055	F	D	81100	99	3.3	C								
1318D	02-3055	M	C	81100	96	4.2	C								
1342T	01-3162	F	F	81268	100	3.1	C								
1345A	01-3163	M	E	81272	83	3.5	C								
1353A	01-3223	M	G	81342	97	2.5	C								
1358S	01-3264	F	H	82020	101	3.5	C								
1368B	01-3318	M	I	82097	88	3.7	C								
1376U	01-3388	F	J	82225	89	2.7	C								
1380W	02-3410	F	L	82267	97	3.8	C								
1386B	01-3433	M	K	82326	97	4.1	C								

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
KBQ/KG REPRESENTS KILOBEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDE
CAUTION: THE RECONSTRUCTED INITIAL LUNG BURDENS, DENOTED BY (R) AND (REC) IN THIS TABLE MAY BE TOO HIGH BECAUSE OF CURREN
ANALYTICAL RADIOCHEMICAL PROBLEMS. THIS MAY LEAD TO CALCULATED ORGAN DOSES THAT ARE TOO HIGH. THIS PROBLEM IS ES
IMPORTANT FOR DOGS IN THE LOWER EXPOSURE LEVELS.

ed)

E ALPHA RADIATION DOSE (GY)

0-93 TO DEATH			DAYS		
C MBC LUNG	REC. LUNG	DEATH DATE	TO 9-30 1993	TO DEATH	COMMENT
1.5		93028		4922	E-MULTIPLE MYELOMA
2.5		93155		4410	E-CARCINOMA,LUNG
	23.	86135		1834	E-CARCINOMA,LUNG
1.7		87209		2273	E-CARCINOMA,LUNG
1.9		92171		4693	D-CARCINOMA,LUNG; CARCINOMA,THYROID
			4209		
			4003		
			4003		
1.5		90159		2859	D-HISTIOCYTIC SARCOMA; ADENOCARCINOMA, LUNG
			4069		
			4411		
0.88		92213		4727	D-LYMPHOSARCOMA
			4069		
			4424		
			4556		
			4318		
0.46		92105		3877	E-CARCINOMA,MAMMARY GLAND; CARCINOMA,LIVER
	2.1	81332		844	D-EPILEPSY
			4425		
			4047		
0.12		83131		488	E-UNDETERMINED
0.31		93014		3788	D-RHABDOMYOSARCOMA,HEART
			3968		
			3968		
			4283		
			4391		
			5161		
0.14		93080		4975	D-FIBROSIS,HEART
0.11		92227		4756	E-MALIGNANT MELANOMA,MOUTH
			4424		
			4003		
			4003		
			4413		
0.058		91017		3570	E-CARCINOMA,NASAL CAVITY;CARCINOMA,LUNG
0.063		93120		4404	D-CARCINOMA,MAMMARY GLAND
			4300		
0.030		86105		1832	E-NEUROFIBROSARCOMA,PERITONEUM
0.038		91004		3199	E-FIBROSARCOMA,LIVER
			4300		
0.026		92199		3973	E-CARCINOMA,TONSIL
0.051		93267		5155	D-NECROSIS,LIVER
			4199		
		80113		250	D-ACUTE PULMONARY EDEMA
		93022		4896	E-LYMPHOSARCOMA
			4556		
		93062		4345	E-LYMPHOSARCOMA
			4388		
			4384		
		92101		3776	D-MAST CELL SARCOMA
		92360		3992	D-SARCOMA,KIDNEY
			4194		
			4066		
			4024		
			3965		

FINDINGS ARE INCLUDED.
IGN BECAUSE OF CURRENT
. THIS PROBLEM IS ESPECIALLY

A.23 $^{239}PuO_2$ Monodisperse Aerosol (1.5 μm AMAD), Aged Longevity Study

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION D TO DEATH	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	REC LUN
412C	02-2754	M	C	79101	3520	10.8	01	0.66	7.1	24.	260.		35.	
503A	01-2878	M	E	79282	3256	12.9	02	0.53	6.9	20.	260.	280		23.
482S	02-2878	F	H	79282	3352	9.5	03	0.57	5.4	21.	200.	220		51.
606T	01-2954	F	L	80176	3068	9.8	04	0.52	5.1	19.	190.	96		7.
385B	01-2760	M	A	79115	3649	11.7	05	0.39	4.6	14.	170.		33.	
637T	02-2954	F	L	80176	2942	9.8	06	0.40	3.9	15.	140.	120		35.
450S	04-2812	F	F	79144	3382	10.9	07	0.34	3.7	13.	140.	230		29.
637A	02-3344	M	I	82169	3666	11.7	08	0.32	3.8	12.	140.	340		24.
363T	01-2754	F	D	79101	3760	9.7	09	0.29	2.8	11.	100.	110		12.
351C	03-2752	M	C	79100	3784	10.4	10	0.26	2.7	9.6	100.	93		26.
729D	01-3348	M	K	82182	3304	8.8	11	0.24	2.1	8.9	78.	250		28.
519U	02-2928	F	J	80045	3295	11.0	12	0.23	2.5	8.5	93.	93		26.
693A	01-3344	M	G	82169	3443	10.8	13	0.23	2.5	8.5	93.	260		20.
492T	01-2880	F	H	79283	3315	9.8	14	0.22	2.3	8.1	85.	74		20.
389A	02-2812	M	A	79144	3665	12.9	15	0.19	2.4	7.0	89.	120		21.
360U	03-2812	F	B	79144	3812	9.9	16	0.17	1.7	6.3	63.		4.6	
590S	01-2928	F	J	80045	3022	8.1	17	0.17	1.4	6.3	52.	41		18.
365S	03-2756	F	D	79102	3757	10.6	18	0.16	1.7	5.9	63.	100		21.
424T	01-2812	F	F	79144	3480	11.2	19	0.15	1.7	5.6	63.	100		23.
483S	03-2880	F	H	79283	3344	11.9	20	0.14	1.7	5.2	63.		13.	
378S	03-2758	F	B	79114	3687	12.1	21	0.13	1.6	4.8	59.	63		19.
343U	02-2756	F	D	79102	3826	11.6	22	0.13	1.5	4.8	56.		7.6	
723B	01-3342	M	G	82167	3301	9.9	23	0.12	1.2	4.4	44.	160		32.
638A	03-3342	M	K	82167	3661	9.5	24	0.12	1.1	4.4	41.	200		23.
682B	02-3342	M	I	82167	3482	11.0	25	0.10	1.1	3.7	41.	170		14.
480T	02-2814	F	F	79145	3215	8.8	26	0.11	0.98	4.1	36.	56		21.
503B	03-2878	M	E	79282	3256	12.9	27	0.10	1.3	3.7	48.	59		16.
346S	02-2758	F	B	79114	3829	11.7	28	0.10	1.2	3.7	44.	52		16.
627S	01-2956	F	L	80177	2973	8.8	29	0.10	0.87	3.7	32.		17.	
466A	02-2880	M	E	79283	3411	10.4	30	0.092	0.96	3.4	36.	36		15.
359D	02-2752	M	C	79100	3768	7.8	31	0.083	0.65	3.1	24.	28		17.
387B	03-2814	M	A	79145	3676	11.6	32	0.075	0.87	2.8	32.	56		18.
375T	01-2756	F	D	79102	3679	10.6	33	0.073	0.78	2.7	29.	37		12.
595T	01-2930	F	J	80042	3154	9.9	34	0.066	0.65	2.4	24.	32		13.
692B	03-3340	M	K	82166	3443	8.2	35	0.068	0.56	2.5	21.	41		23.
785B	02-3340	M	I	82166	2986	9.1	36	0.066	0.60	2.4	22.	41		22.
681D	01-3340	M	G	82166	3486	10.1	37	0.062	0.63	2.3	23.	110		24.
378C	01-2752	M	C	79100	3673	10.8	38	0.047	0.51	1.7	19.	27		14.
370S	01-2758	F	B	79114	3710	8.1	39	0.048	0.39	1.8	14.		7.0	
639S	02-2956	F	L	80177	2935	13.4	40	0.032	0.43	1.2	16.		7.6	
536S	02-2930	F	J	80046	3263	11.7	41	0.034	0.40	1.3	15.	21		8.
719A	04-3342	M	K	82137	3321	12.5	42	0.027	0.34	1.0	13.	31		13.
467S	01-2814	F	F	79145	3265	12.3	43	0.024	0.30	0.89	11.	35		16.
484A	01-2882	M	E	79284	3345	11.5	44	0.026	0.30	0.96	11.	29		14.
719B	01-3338	M	G	82162	3316	10.5	45	0.022	0.23	0.81	8.5	27		10.
346B	01-2762	M	A	79116	3831	12.7	46	0.024	0.31	0.89	11.	19		1.
477S	02-2882	F	H	79284	3363	12.0	47	0.023	0.28	0.85	10.		4.5	
731B	02-3338	M	I	82162	3272	6.7	48	0.013	0.09	0.48	3.3		2.9	

IVE ALPHA RADIATION DOSE (GY)

TO DEATH

MDC LUNG	REC. LUNG	DEATH DATE	DAYS TO DEATH	COMMENT
35.		80033	297	D-PNEUMONITIS
	23.	80121	204	D-PLEURITIS (NOCARDIA SP.)
	51.	81057	506	E-PNEUMONITIS AND PULMONARY FIBROSIS
	7.5	80317	141	E-CARCINOMA, MAMMARY GLAND
33.		80270	520	D-PNEUMONITIS
	35.	82126	681	E-PNEUMONITIS AND PULMONARY FIBROSIS
	29.	80059	280	E-PNEUMONITIS
	24.	82321	152	D-PNEUMONITIS AND PULMONARY FIBROSIS
	12.	79309	208	D-PNEUMONITIS
	26.	81100	731	D-PULMONARY FIBROSIS
	28.	83007	190	E-LYMPHOSARCOMA-LIVER
	26.	82116	802	E-PNEUMONITIS AND PULMONARY FIBROSIS
	20.	82316	147	E-PNEUMONITIS AND PULMONARY FIBROSIS
	20.	81199	647	D-PNEUMONITIS AND PULMONARY FIBROSIS
	21.	80273	494	E-PNEUMONITIS
4.6		79273	129	D-PNEUMONITIS
	18.	82322	1008	E-PNEUMONITIS AND PULMONARY FIBROSIS
	21.	80234	497	D-PNEUMONITIS
	23.	80358	579	E-PNEUMONITIS AND PULMONARY FIBROSIS
13.		81153	601	E-PNEUMONITIS AND PULMONARY FIBROSIS
	19.	82012	994	D-PERITONITIS
7.6		80070	333	D-PNEUMONITIS
	32.	83259	457	E-PNEUMONITIS AND PULMONARY FIBROSIS
	23.	83014	212	D-PNEUMONITIS AND PULMONARY FIBROSIS
	14.	82334	167	D-PNEUMONITIS AND PULMONARY FIBROSIS
	21.	81350	936	D-LYMPHOSARCOMA-DUODENUM
	16.	82113	927	E-PNEUMONITIS AND PULMONARY FIBROSIS
	16.	81361	978	D-PNEUMONITIS AND PULMONARY FIBROSIS
17.		84125	1409	E-PNEUMONITIS AND PULMONARY FIBROSIS
	15.	83080	1258	E-PNEUMONITIS AND PULMONARY FIBROSIS
	17.	83105	1466	E-PNEUMONITIS AND PULMONARY FIBROSIS
	18.	82061	1012	D-CARDIAC FAILURE
	12.	81249	878	E-PNEUMONITIS AND PULMONARY FIBROSIS
	13.	83067	1117	E-PNEUMONITIS AND PULMONARY FIBROSIS
	23.	86184	1479	D-ISLET CELL CARCINOMA,PANCREAS
	22.	86286	1581	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
	24.	83291	490	E-PNEUMONITIS AND PULMONARY FIBROSIS
	14.	84166	1892	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
7.0		82123	1105	D-ACCIDENTAL DEATH
7.6		88096	2841	E-CARCINOMA,LUNG
	8.2	83290	1340	E-CARCINOMA,TONSIL
	13.	87149	1808	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
	16.	84316	1997	D-THROMBOSIS,LUNG
	14.	85081	1989	E-PNEUM. AND PUL. FIBROSIS;PUL. CARC.
	10.	85179	1113	E-LIVER,DEGENERATION
	1.9	80004	253	E-MALIGNANT MELANOMA
4.5		84279	1821	E-PNEUMONITIS AND PULMONARY FIBROSIS
2.9		88153	2182	E-VISCERAL LYMPHOSARCOMA

A.23 $^{239}PuO_2$ Monodisperse Aerosol (1.5 μm AMAD), Aged Longevity Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE				ILB (WBC)					ILB (R)	CUMULATIVE ALPHA RADIATION DOSE TO DEATH	
TATTOO	AN-EXPT	SEX	BLOCK	DATE	AGE DAYS	WT KG	RANK	UCI/KG	UCI	KBQ/KG	KBQ	KBQ	WBC LUNG	REC. LUNG
361S	02-2764	F	D	79103	3771	12.7	C							
367A	01-2764	M	C	79103	3742	11.9	C							
373S	01-2757	F	B	79113	3694	7.5	C							
398C	02-2757	M	A	79113	3575	12.6	C							
459U	01-2815	F	F	79149	3319	10.5	C							
495S	02-2883	F	H	79285	3292	10.1	C							
510A	01-2883	M	E	79285	3208	9.5	C							
564T	01-2932	F	J	80046	3154	9.9	C							
625S	01-2952	F	L	80177	2977	9.9	C							
655B	02-3346	M	I	82168	3621	8.9	C							
713A	01-3346	M	G	82168	3370	10.4	C							
785A	03-3346	M	K	82168	3002	8.3	C							

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UCI/KG REPRESENTS MICROCURIES OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
KBQ/KG REPRESENTS KILOBEQUERELS OF RADIONUCLIDE PER KILOGRAM OF TOTAL BODY WEIGHT.
DOSE RATE AND CUMULATIVE DOSE ARE PRESENTED AS FUNCTIONS OF TIME IN DAYS AFTER INHALATION EXPOSURE.
COMMENT: D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDE
CAUTION: THE RECONSTRUCTED INITIAL LUNG BURDENS, DENOTED BY (R) AND (REC) IN THIS TABLE MAY BE TOO HIGH BECAUSE OF CURREN
ANALYTICAL RADIOCHEMICAL PROBLEMS. THIS MAY LEAD TO CALCULATED ORGAN DOSES THAT ARE TOO HIGH. THIS PROBLEM IS ES
IMPORTANT FOR DOGS IN THE LOWER EXPOSURE LEVELS.

ALPHA RADIATION DOSE (GY)

TO DEATH

REC. LUNG	DEATH DATE	DAYS TO DEATH	COMMENT
	85087	2176	E-CARCINOMA,MOUTH
	85358	2447	E-ADENOCARCINOMA,LUNG
	83327	1675	E-ADENOCARCINOMA,MAMMARY
	83031	1379	E-TONSIL SQUAMOUS CELL CARCINOMA
	82342	1289	D-CARCINOMA,KIDNEY
	81139	585	D-ACCIDENTAL DEATH
	85225	2132	D-BRONCHOPNEUMONIA,LUNG
	85141	1922	E-MELANOMA,MOUTH
	86352	2369	D-CONGESTIVE HEART FAILURE
	85012	926	D-CHEMODECTOMA,MALIGNANT
	87051	1695	E-NEPHRITIS,KIDNEY
	88090	2099	E-CARCINOMA,BLADDER

INDINGS ARE INCLUDED.
N BECAUSE OF CURRENT
THIS PROBLEM IS ESPECIALLY

A.24 $^{239}PuO_2$ Monodisperse Aerosol (0.75 μm AMAD), Repeated Exposure Study

DOG IDENTIFICATION			INHALATION EXPOSURE		FIRST EXPOSURE			TLB (WBC)					MAXIMUM ALPHA	CUMULA ALPHA RA DOSE TO
TATTOO	AN-EXPT	SEX	GROUP	BLOCK	DATE	AGE DAYS	WT KG	NCI/KG	NCI	KBQ/KG	KBQ	NUMBER OF EXPOSURES	DOSE RATE GY/DAY	TO
1028A	01-2244	M	I	A	77229	433	11.1	14	150	0.52	5.6	1	.0032	
1036A	02-2244	M	I	C	77229	406	11.7	7	80	0.26	3.0	1	.0016	
1025A	03-2244	M	I	C	77229	437	12.0	16	190	0.59	7.0	1	.0038	
1028B	04-2244	M	I	A	77229	433	9.0	9	80	0.33	3.0	1	.0021	
1044U	01-2266	F	I	B	77243	379	7.7	12	90	0.44	3.3	1	.0028	
1050B	02-2266	M	I	E	77243	368	10.8	17	180	0.63	6.7	1	.0040	
1040S	03-2266	F	I	B	77243	395	8.8	10	90	0.37	3.3	1	.0025	
1050A	04-2266	M	I	E	77243	368	11.2	10	110	0.37	4.1	1	.0024	
1055W	01-2292	F	I	D	77271	387	8.1	19	150	0.70	5.6	1	.0044	
1050S	02-2292	F	I	D	77271	396	9.4	15	140	0.56	5.2	1	.0036	
1051B	03-2292	M	I	G	77271	395	11.3	13	150	0.48	5.6	1	.0032	
1058B	04-2292	M	I	G	77271	369	10.0	15	150	0.56	5.6	1	.0036	
1061A	01-2318	M	I	I	77291	371	10.3	20	210	0.74	7.8	1	.0049	
1060S	02-2318	F	I	F	77291	384	10.3	17	170	0.63	6.3	1	.0040	
1055T	03-2318	F	I	F	77291	407	9.9	17	170	0.63	6.3	1	.0041	
1060B	04-2318	M	I	I	77291	384	9.9	13	130	0.48	4.8	1	.0031	
1063C	01-2348	M	I	K	77312	390	9.1	12	110	0.44	4.1	1	.0029	
1067B	02-2348	M	I	K	77312	371	8.4	12	100	0.44	3.7	1	.0029	
1061T	03-2348	F	I	H	77312	392	8.5	25	210	0.93	7.8	1	.0059	
1062S	04-2348	F	I	H	77312	391	8.9	19	170	0.70	6.3	1	.0046	
1077U	01-2388	F	I	L	78010	405	7.9	33	260	1.2	9.6	1	.0079	16
1077V	02-2388	F	I	J	78010	405	8.0	26	210	0.96	7.8	1	.0063	11
1073T	03-2388	F	I	L	78010	417	8.4	70	590	2.6	22.	1	.017	15
1077S	04-2388	F	I	J	78010	405	8.4	25	210	0.93	7.8	1	.0060	9
1027C	03-2246	M	II	A	77230	435	12.4	130	1500	5.0	54.	10	.018	23
1040C	04-2246	M	II	C	77230	382	10.1	120	1300	4.4	47.	9	.018	17
1036S	01-2268	F	II	B	77244	421	9.6	120	1200	4.3	46.	9	.016	16
1045D	02-2268	M	II	E	77244	379	10.6	140	1500	5.0	55.	10	.018	22
1055U	01-2294	F	II	D	77272	388	8.6	130	1200	4.7	43.	10	.018	20
1051D	03-2294	M	II	G	77272	396	10.7	120	1200	4.3	46.	9	.017	20
1062B	01-2320	M	II	I	77292	371	12.3	150	2000	5.6	75.	10	.021	27
1049S	03-2320	F	II	F	77292	419	9.8	110	1200	4.1	45.	8	.017	14
1061S	01-2350	F	II	H	77313	393	8.4	180	1600	6.8	58.	9	.027	26
1064A	02-2350	M	II	K	77313	391	10.3	150	1500	5.4	54.	9	.021	24
1070S	01-2390	F	II	L	78011	421	8.2	140	1300	5.3	49.	10	.023	30
1069S	04-2390	F	II	J	78011	424	10.2	180	1800	6.7	67.	9	.028	31
1037B	01-2248	M	III	C	77231	397	9.7	23	240	0.85	8.9	20	.0027	7
1025B	02-2248	M	III	A	77231	439	10.7	21	220	0.78	8.3	18	.0024	6
1027B	03-2248	M	III	A	77231	436	10.9	13	160	0.48	6.0	12	.0017	2
1035A	04-2248	M	III	C	77231	410	8.5	24	210	0.89	7.9	19	.0026	8
1041B	01-2272	M	III	E	77245	384	9.6	24	240	0.89	8.9	19	.0026	6
1046B	02-2272	M	III	E	77245	378	7.2	25	200	0.93	7.5	16	.0027	6
1035U	03-2272	F	III	B	77245	424	7.4	24	180	0.89	6.8	16	.0029	8
1029U	04-2272	F	III	B	77245	446	8.4	27	220	1.0	8.1	18	.0030	7
1054B	01-2296	M	III	G	77273	392	9.6	24	260	0.89	9.6	17	.0026	6
1057A	02-2296	M	III	G	77273	371	10.1	30	330	1.1	12.	20	.0030	11
1046T	03-2296	F	III	D	77273	406	7.3	11	85	0.41	3.1	2	.0024	0
1051S	04-2296	F	III	D	77273	397	9.0	34	330	1.3	12.	19	.0035	10
1051A	01-2322	M	III	I	77293	417	11.7	26	300	0.96	11.	18	.0027	8
1057S	02-2322	F	III	F	77293	391	8.5	24	210	0.89	7.9	18	.0027	6
1057T	03-2322	F	III	F	77293	391	9.4	26	230	0.96	8.3	20	.0029	8
1058C	04-2322	M	III	I	77293	391	10.3	19	210	0.70	7.8	20	.0021	6

F S	MAXIMUM ALPHA DOSE RATE GY/DAY	CUMULATIVE ALPHA RADIATION DOSE TO LUNG (GY) TO DEATH	DEATH DATE	DAYS FROM FIRST EXPOSURE TO 9-30-93	DEATH	COMMENT
	.0032	5.9	88284		4072	E-DISSEMINATED SARCOMA
	.0016	2.9	88083		3871	E-PAPILLARY ADENOCARCINOMA,LUNG
	.0038	6.3	87189		3612	E-CARCINOMA,LUNG
	.0021	3.6	87317		3740	D-CONGESTIVE FAILURE,HEART
	.0028	5.6	90290		4795	E-CARCINOMA,LUNG
	.0040	8.1	90351		4856	E-MULTIPLE CARCINOMA,LUNG
	.0025	2.5	82068		1651	D-IMMUNE HEMOLYTIC ANEMIA
	.0024	5.0	92023		5258	E-CARCINOMA,LUNG
	.0044	9.1	91137		4979	E-CARCINOMA,LUNG
	.0036	5.9	87183		3564	D-HEPATIC DEGENERATION;CARCINOMA,LUNG
	.0032	5.5	88063		3809	D-PAPILLARY ADENOCARCINOMA,LUNG
	.0036	6.8	89236		4348	E-ADENOSQUAMOUS CARCINOMA,LUNG
	.0049	7.8	86343		3339	E-CARCINOMA,LUNG
	.0040	6.4	87105		3466	E-ADENOCARCINOMA,MAMMARY GLAND
	.0041	6.8	87197		3558	E-CARCINOMA,LUNG
	.0031	4.4	85084		2715	E-CARCINOMA,LUNG
	.0029	5.1	88196		3901	D-MALIGNANT MIXED TUMOR,LUNG
	.0029	6.3	92351		5517	D-CARCINOMA,LUNG
	.0059	9.6	87125		3465	E-CARCINOMA,LUNG
	.0046	3.5	80247		1030	E-VERTEBRAL DISC HERNIATION
	.0079	16.	90338		4711	E-CARCINOMA,LUNG
	.0063	11.	89089		4097	E-PAPILLARY ADENOCARCINOMA,LUNG
	.017	15.	83104		1920	E-PNEUMONITIS AND PUL. FIBROSIS;PUL. CARC.
	.0060	9.3	86304		3216	D-CARCINOMA,LUNG
	.018	23.	83047		2008	E-PNEUMONITIS AND PULMONARY FIBROSIS
	.018	17.	82088		1684	E-PNEUMONITIS AND PULMONARY FIBROSIS
	.016	16.	82041		1623	E-PNEUMONITIS AND PULMONARY FIBROSIS
	.018	22.	82326		1908	D-PNEUMONITIS AND PUL. FIBROSIS;PUL. CARC.
	.018	20.	83025		1944	E-PNEUMONITIS AND PULMONARY FIBROSIS
	.017	20.	82341		1895	E-PNEUMONITIS AND PULMONARY FIBROSIS
	.021	27.	83114		2013	D-PNEUMONITIS AND PULMONARY FIBROSIS
	.017	14.	81293		1462	E-PNEUMONITIS AND PULMONARY FIBROSIS
	.027	26.	82118		1631	E-PNEUMONITIS AND PULMONARY FIBROSIS
	.021	24.	82316		1829	E-PNEUMONITIS AND PUL. FIBROSIS;PUL. CARC.
	.023	30.	84194		2374	D-B.A. CARC.,LUNG;OSTEOSARCOMA,MANDIBLE
	.028	31.	83077		1892	D-PULMONARY CARCINOMA
	.0027	7.1	87222		3643	E-CARCINOMA,LUNG
	.0024	6.3	87292		3713	E-SQUAMOUS CARCINOMA,LUNG
	.0017	2.5	83165		2125	D-RUPTURED GALL BLADDER
	.0026	8.1	89220		4372	E-PAPILLARY ADENOCARCINOMA,LUNG
	.0026	6.4	86335		3377	E-CARCINOMA,LUNG
	.0027	6.1	85356		3033	D-CARCINOMA,PITUITARY
	.0029	8.0	88362		4134	E-TRANSITIONAL CELL CARCINOMA,BLADDER
	.0030	7.4	87164		3571	E-CARCINOMA,LUNG
	.0026	6.5	86191		3205	E-ADENOCARCINOMA,LUNG
	.0030	11.	89030		4140	E-PAPILLARY ADENOCARCINOMA,LUNG
	.0024	0.86	78272		364	D-ACCIDENTAL DEATH
	.0035	10.	87238		3617	E-CARCINOMA,LUNG
	.0027	8.0	87230		3589	E-CARCINOMA,LUNG
	.0027	6.6	87104		3463	E-CARCINOMA,LUNG
	.0029	8.9	89354		4444	D-BRONCHOPNEUMONIA
	.0021	6.2	89163		4253	D-PAPILLARY ADENOCARCINOMA,LUNG

A.24 $^{239}PuO_2$ Monodisperse Aerosol (0.75 μm AMAD), Repeated Exposure Study (continued)

DOG IDENTIFICATION			INHALATION EXPOSURE		FIRST EXPOSURE			TLB (WBC)				NUMBER OF EXPOSURES	MAXIMUM ALPHA DOSE RATE GY/DAY	CUMULATIVE ALPHA RADIATI DOSE TO LUNG (TO DEATH
TATTOO	AN-EXPT	SEX	GROUP	BLOCK	DATE	AGE DAYS	WT KG	NCI/KG	NCI	KBQ/KG	KBQ			
1055S	01-2352	F	III	H	77314	430	8.9	38	350	1.4	13.	19	.0037	11.
1066A	02-2352	M	III	K	77314	378	9.0	32	290	1.2	11.	20	.0031	11.
1065B	03-2352	M	III	K	77314	391	10.1	26	270	0.96	10.	19	.0026	8.2
1067T	04-2352	F	III	H	77314	373	8.9	32	300	1.2	11.	20	.0031	11.
1071S	01-2392	F	III	J	78012	421	8.6	23	210	0.85	7.9	19	.0026	7.8
1070U	02-2392	F	III	J	78012	422	9.7	17	170	0.63	6.4	14	.0022	3.8
1073U	03-2392	F	III	L	78012	419	8.5	22	210	0.81	7.6	12	.0029	4.2
1078S	04-2392	F	III	L	78012	401	10.2	20	220	0.74	8.0	20	.0024	6.2
1037A	01-2246	M	S	C	77230	400	10.3	160	1700	6.1	62.	8	.025	22.
1041A	02-2246	M	S	A	77230	369	10.0	54	580	2.0	21.	4	.010	4.1
1037T	03-2268	F	S	B	77244	414	8.5	170	1500	6.4	54.	10	.022	26.
1040D	04-2268	M	S	E	77244	396	10.3	23	250	0.85	9.3	2	.0051	1.1
1054D	02-2294	M	S	G	77272	391	7.9	200	1700	7.3	61.	10	.027	31.
1049T	04-2294	F	S	D	77272	399	9.7	28	280	1.0	10.	2	.0056	1.5
1054C	02-2320	M	S	I	77292	411	7.0	180	1300	6.5	47.	9	.025	29.
1049V	04-2320	F	S	F	77292	419	9.3	160	1500	5.9	57.	7	.028	17.
1065T	03-2350	F	S	H	77313	390	7.9	81	640	3.0	24.	4	.016	6.0
1064C	04-2350	M	S	K	77313	391	8.5	46	410	1.7	15.	2	.0088	2.5
1067U	02-2390	F	S	J	78011	435	6.9	88	700	3.3	26.	9	.015	13.
1078T	03-2390	F	S	L	78011	400	10.2	41	470	1.5	17.	4	.0075	3.2
1037E	01-2249	M	C	A	77231	401	10.0							
1040A	02-2249	M	C	C	77231	383	13.5							
1044T	01-2270	F	C	B	77244	380	7.1							
1043A	02-2270	M	C	E	77244	382	10.8							
1058A	01-2293	M	C	G	77271	369	10.0							
1051T	02-2293	F	C	D	77271	395	7.5							
1058S	01-2324	F	C	F	77305	403	10.5							
1062A	02-2324	M	C	I	77305	384	11.2							
1066T	01-2347	F	C	H	77312	376	7.0							
1062C	02-2347	M	C	K	77312	391	11.5							
1077T	01-2394	F	C	L	78045	440	8.8							
1068V	02-2394	F	C	J	78045	464	9.5							

****

EXPOSURE GROUPS:
- GROUP I: SINGLE EXPOSURE TO 0.1UCI; THEN SHAM EXPOSURE EVERY 182 DAYS.
- GROUP II: LUNG BURDEN INCREASED 0.1UCI EVERY 182 DAYS.
- GROUP III: LUNG BURDEN INCREASED 0.01UCI EVERY 182 DAYS.
- GROUP S: SACRIFICE SERIES; EXPOSURES AS FOR GROUP II.
- GROUP C: CONTROLS; SHAM EXPOSURE EVERY 182 DAYS.

NOTES:
- TLB (WBC)= TOTAL PLUTONIUM ACTIVITY INHALED BASED ON WHOLE BODY COUNTS OF 169YB TAG.
- DOSE AND DOSE RATE ARE FOR LUNG AND INCLUDE ACTIVITY IN TRACHEOBRONCHIAL LYMPH NODES.
- D, E, OR S INDICATE THE DOG DIED, WAS EUTHANIZED OR WAS SACRIFICED, RESPECTIVELY. PROMINENT FINDINGS ARE INCLUDED.

ntinued)

MAXIMUM ALPHA DOSE RATE GY/DAY	CUMULATIVE ALPHA RADIATION DOSE TO LUNG (GY) TO DEATH	DEATH DATE	DAYS FROM FIRST EXPOSURE TO 9-30-95	DEATH	COMMENT
.0037	11.	87195		3533	E-CARCINOMA,LUNG
.0031	11.	89225		4294	D-PAPILLARY ADENOCARCINOMA,LUNG
.0026	8.2	88224		3927	E-PAPILLARY ADENOCARCINOMA,LUNG
.0031	11.	89213		4282	D-PAPILLARY ADENOCARCINOMA,LUNG
.0026	7.8	89220		4226	E-HEMANGIOSARCOMA,VERTEBRA
.0022	3.8	84271		2450	E-MELANOMA,OROPHARYNX
.0029	4.2	83118		1933	D-ACCIDENTAL DEATH
.0024	6.2	87349		3624	E-PAPILLARY ADENOCARCINOMA,LUNG
.025	22.	81299		1530	E-PNEUMONITIS AND PULMONARY FIBROSIS
.010	4.1	79228		728	S-SACRIFICED
.022	26.	82116		1698	D-PNEUMONITIS AND PULMONARY FIBROSIS
.0051	1.1	78243		364	S-SACRIFICED
.027	31.	82284		1838	S-SACRIFICED
.0056	1.5	78276		369	S-SACRIFICED
.025	29.	82298		1832	S-SACRIFICED
.028	17.	81098		1267	E-PNEUMONITIS AND PULMONARY FIBROSIS
.016	6.0	79311		728	S-SACRIFICED
.0088	2.5	78312		364	S-SACRIFICED
.015	13.	82299		1749	S-SACRIFICED
.0075	3.2	80015		734	S-SACRIFICED
		91198		5080	E-MELANOMA,MOUTH
		83290		2250	D-ACCIDENTAL DEATH
		93060		5660	E-MYXOSARCOMA,SUBCUTIS
		88168		3941	E-CARCINOMA,PERIANAL GLAND
		92157		5364	E-NEPHROPATHY,KIDNEY
		89096		4208	D-CONGESTIVE HEART FAILURE
		93105		5644	E-CARCINOMA,PANCREAS
		80179		969	D-STRANGULATED HERNIA
			5805		
		91249		5050	D-BRONCHOPNEUMONIA
		91029		4732	E-CARCINOMA,PITUITARY
		90045		4383	E-ADENOCARCINOMA,MAMMARY GLAND

T FINDINGS ARE INCLUDED.

APPENDIX B: STATUS OF LONGEVITY AND SACRIFICE STUDIES IN BEAGLE DOGS FROM THE UNIVERSITY OF UTAH (9/30/93)

This appendix contains detailed tabular information through September 30, 1993, on all dogs in the life-span studies and many related sacrifice series associated with these studies that have been initiated at the University of Utah over the past 35 years. All of the dogs remaining alive in the life-span studies at the University of Utah were transferred to the Lovelace ITRI colony on September 15, 1987, where they are being maintained and studied for the remainder of their life spans. Responsibility for managing the completion of the Utah life-span studies has been assigned to ITRI, with input from a small team of investigators at the University of Utah and investigators at ITRI.

Appendix tables of this kind have been an important part of the annual reports from the Utah studies, and they will be continued as part of future ITRI annual reports. For consistency, the format of the Utah tables is similar to that used in past reports.

The following tables detailed information on the toxicity and test animals, respectively. Toxicity animals are those animals that were usually maintained until sacrifice became a clinical necessity; test animals were sacrificed as needed for special studies.

Dogs were put into the toxicity study at graded injection levels. At each level, about half the dogs were male and half female. Litter mates were used whenever possible. Abnormal dogs were excluded. Each animal received the designated quantity of one radionuclide in a single intravenous injection of 0.08 molar citrate solution at pH 3.5. Unless otherwise specified, the radionuclides were monomeric (either ionic or complexed with citrate).

The five injection levels designated by integers are those specified at the early meetings of the consultants; those designated by nonintegers have been added by the laboratory staff. Since those injection levels were originally specified in "retained" activities, the actual injections were four times the desired "retained" μCi/kg for ^{90}Sr, ^{210}Pb, ^{224}Ra, ^{226}Ra, and ^{228}Ra, and 1.11 times the desired "retained" μCi/kg for ^{228}Th, ^{239}Pu, ^{241}Am, $^{243/244}Cm$, $^{249/252}Cf$, and ^{253}Es.

$$\text{Level 1} = 10 \times \frac{0.1\ \mu\text{Ci}\ ^{226}\text{Ra}}{70\ \text{kg man}} = 0.0143\ \text{retained}\ \mu\text{Ci/kg}$$

The desired "retained" activities were the same for all the radionuclides except ^{90}Sr, in which case they were greater by a factor of 10. Injection level 1 was the basis of the scheme, and was 10 times the maximum permissible concentration of ^{226}Ra in man.

Since radioactive decay and excretion occur continuously, the term "total body retention" is meaningless unless the time after injection is specified. Our present measurements indicate that the effective retention of alkaline earth elements and ^{210}Pb decrease to about 25% of that injected by the following times after injection:

Element	Time (days)
^{90}Sr	134
^{210}Pb	98
^{224}Ra	5
^{226}Ra	271
^{228}Ra	214

Retention of actinide elements decreased to about 90% at post-injection times shown below:

^{228}Th	6
^{239}Pu	6
^{241}Am	6
$^{243244}Cm$	1
^{253}Es	1

All other injection levels were simple multiples of level 1, as shown below.

Level 0.1 is 1/27 of level 1

Level 0.2 is 1/9 of level 1

Level 0.5 is 1/3 of level 1

Level 0.7 is 2/3 of level 1

Level 1.5 is 2 times level 1

Level 1.7 is 3 times level 1

Level 2 is 6 times level 1

Level 3 is 18 times level 1

Level 4 is 54 times level 1

Level 4.5 is 94 times level 1

Level 5 is 162 times level 1.

The numbering system for the dogs was built around the injection program and serves as a code to describe each dogs place in the experiment. The first letter tells the sex of toxicity animals (M = male; F = female). When the first letter is T, the dog is a test animal. M, F, or T is followed by a number which denotes chronological order of the individual test dogs, or of groups, in the case of toxicity dogs.

Next comes a code letter for the radionuclide: C=$^{243/244}Cm$; E=^{253}Es; F=^{252}Cf; G=^{249}Cf; J=^{85}Sr; K=$^{237,241}Pu$; L=^{210}Pb; M=^{228}Ra; P=^{239}Pu; Q=^{224}Ra; R=^{226}Ra; S=^{90}Sr; T=^{228}Th; U=$^{233,232}U$; V=^{238}U; W=^{241}Am; A=ancillary (nonradioactive).

"A" following the regular dog number means that the dog is a replacement; "H" following the regular dog number means that the dog received more than one injection. "B", "C" or "D" denotes an intended special assignment, but most of these dogs have been redesignated for life-span toxicity studies. "E" in the final position is used to denote that the dog listed is a St. Bernard. "P" in the final position indicates that the nuclide was polymeric (injected in a particulate form). "Y" in the final position indicates that the animal was injected as a juvenile. "N" in the final position indicates that the animal was injected as a neonate. A plus (+) in the final position denotes that the animal was "old" when injected. Letters denoting a radionuclide may follow the final number, in which case the letter indicates that two radionuclides were given. The injection level refers to the radionuclide appearing first in the identifying code.

Example: M1R5 is a male animal in the first radium group at the highest injection level.

Although M1R5, M1R4, M1R3, M1R2, M1R1, and M1R0 constitute a group and were injected at the same time, the tables are arranged according to injection level to facilitate comparison of all the R5 animals, all the R4 animals, etc.

The conditions listed in the status tables under "Comments on Dead Dogs" give the cancers and the lesions that had the most apparent effect on the clinical status of the animal. These comments should not be considered as confirmed pathology. For example, multiple rib fractures, which seldom produce symptoms, are not listed, even though their incidence was usually much higher than the crippling fractures involving the limb bones or mandible. The hematological changes have been omitted unless they were extreme. Increased rate of tooth loss, hepatic changes, eye lesions, and many other factors in the various syndromes have not been included because of space limitations. Over the years many soft tissue tumors have been removed surgically. In many instances, the conditions that have been listd were the reasons for sacrifice of the animal but they were not the immediate cause of death. Most of the animals were euthanized when death appeared imminent or when life could no longer be prolonged humanely.

DOSIMETRY

The tables include the calculated average dose in Gy to the skeleton at death. ^{90}Sr, ^{226}Ra, ^{228}Ra, ^{241}Am, ^{249}Cf, and ^{252}Cf doses are calculated for each dog, using its individually observed retention values: ^{239}Pu, ^{228}Th, and ^{224}Ra doses are based on the average retention equations. For the young adult Beagle dogs injected at about 17 mo of age, the following equations were used for the EFFECTIVE skeletal retention at (t) days after injection to account for both radioactive decay and biological elimination. These equations do <u>not</u> apply to St. Bernards (E) or to Beagles injected as neonates (N), young juveniles (Y), old dogs (+), or to dogs receiving polymeric plutonium (P) or chelation therapy.

Detailed retention data and dosimetric analyses were presented or referenced in the 1984 annual report (C00-119-259, December 1984). The skeletal doses are based upon a wet skeleton which is 10% of the body weight at the time of injection (C00-119-257, pp. 89-92, 1982).

^{228}Ra and ^{226}Ra doses deserve special comment. The dose from "pure" ^{228}Ra and its *in vivo* produced daughters is based on our best evaluation of 5.77 0.02 yr for the ^{228}Ra half-period. The tabulated total doses include the contributions from ^{228}Th contamination in the injection solutions. For example, ^{228}Th contaminations of 0.6%, 3% and 15%, respectively, account for 3%, 13% and 42% of the total dose in rads at 1000 days. If injected ^{228}Th is four times more toxic rad-for-rad than is *in vivo* produced ^{228}Th, these injected ^{228}Th contamination would account for 10%, 37% and 74% of the total biological damage at 1000 days. Therefore, it may be desirable to use only results from the slightly contaminated (0.6% ^{228}Th) dogs in evaluation of ^{228}Ra toxicity. The contribution from injected ^{210}Pb which occurs in the ^{226}Ra injection solution as a result of ^{226}Ra decay has been included in skeleton dose calculations for ^{226}Ra dogs. This can account for between about 1% and 30% of the total:

^{226}Ra (adults, dose level 5) = $0.20e^{-0.00488t} + 0.29e^{-0.000299t}$

^{226}Ra (adults, lower levels) = $0.21e^{-0.0155T} + 0.18e^{-0.00204t} + 0.15e^{-0.000150t}$

$^{222}Rn/^{226}Ra$ (adults, all levels) = $0.075\ (1-e^{-0.181t})\ t^{0.158}$

^{239}Pu (dose level 5) = $0.07e^{-0.0011t} + 0.43$

^{239}Pu (dose level 4) = $0.11e^{-0.0011t} + 0.39$

^{239}Pu (dose level 3) = $0.15e^{-0.0011t} + 0.34$

^{239}Pu (lower levels) = $0.29e^{-0.0011t} + 0.21$

^{228}Ra (all levels) = $0.21e^{-0.016t} + 0.177e^{-0.0024t} + 0.15e^{-0.00048t}$ (pure at t = 0)
with 84% retention of *in vivo* produced daughters of ^{228}Th.

^{228}Th (all levels) = $0.68e^{-0.00117t}$
with ratios of ^{224}Ra, ^{220}Rn, ^{216}Po, ^{212}Pb, ^{212}Bi to ^{228}Th as a function of ime after injection and of dose level as given in *Radiat. Res.* 98: 614-628, 1984.

^{241}Am (dose level 5) = $0.359 + 0.157\ (1-e^{-0.0065t})$

^{241}Am (dose level 4) = $0.359 + 0.141\ (1-e^{-0.0029t})$

^{241}Am (dose level 3) = $0.359 + 0.076\ (1-e^{-0.0021t})$

^{241}Am (lower levels) = $0.359 + 0.015\ (1-e^{-0.0014t})$

^{249}Cf (all levels) = $0.498e^{-0.0000794t}$

^{252}Cf (all levels) = $0.498e^{-0.000791t}$

^{224}Ra (all levels) = $0.528e^{-0.214t} - 0.228e^{-9.01t}$
with the effective retention of ^{224}Ra daughters for all levels of:

^{220}Rn and ^{216}Po = $0.486e^{-0.214t} - 0.276e^{-4.65t}$

^{212}Pb = $0.447e^{-0.214t} - 0.336e^{-2.40t}$

^{212}Bi = ^{212}Po + ^{208}Tl = $0.391e^{-0.214t} - 0.350e^{-2.38t}$

For the calculation of radiation dose for dogs that had received particulate plutonium, measured skeletal weights were used. The following skeletal Pu-retentions (R_{Skel}) were applied:

1. Dogs that received no further treatment: $R_{Skel} = 60(1 - 0.914e^{0.00098t})e^{-0.000237t}$.
2. Dogs that received 30 mole CaDTPA/kg once weekly: R_{Skel} = 6.7% constant average retention.
3. Dogs that received 30 mole ZnDTPA/kg daily: R_{Skel} = 2.8% constant average retention.

STATUS TABLES

B.1 ^{241}Am, Chronic Toxicity Study

DOG NUMBER	AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F013W02	533	10.6	0.00179	0.0662	OCT-13-66	3815	0.06	UNDETERMINED (NO SKELETAL TUMOR)
M014W02	533	14.9	0.00178	0.0659	OCT-13-66	3185	0.05	HEMANGIOSARCOMA (SOFT TISSUE)
F024W02	477	11.3	0.00181	0.0670	MAR-21-68	4236	0.08	THROMBOEMBOLISM
F031W02	472	10.9	0.00180	0.0666	MAY-08-68	1478	0.03	LUNG CARCINOMA
M041W02	467	11.9	0.00180	0.0666	JUL-02-68	4860	0.09	THYMOMA
M048W02	484	11.0	0.00174	0.0644	JUL-30-68	4705	0.07	MAST CELL SARCOMA
M049W02	498	10.7	0.00175	0.0648	NOV-25-69	4026	0.07	VALVULAR ENDOCARDITIS, PNEUMONIA
F058W02	496	10.4	0.00168	0.0622	JAN-26-70	3157	0.05	TRAUMA
M062W02	485	13.3	0.00175	0.0648	FEB-24-70	4996	0.09	SPONDYLOSIS, LUNG CARCINOMA
F069W02	542	10.8	0.00180	0.0666	APR-22-70	4287	0.07	ENDOMETRITIS
M078W02	501	13.5	0.00178	0.0659	JUL-16-70	4884	0.10	PNEUMONIA
M079W02	501	10.0	0.00179	0.0662	JUL-16-70	4694	0.08	EPIDERMOID CARCINOMA (MOUTH)
F088W02	531	8.36	0.00177	0.0655	AUG-25-70	3335	0.05	PANCREATITIS
M095W02	526	13.1	0.00173	0.0640	AUG-25-70	4129	0.08	LYMPHOSARCOMA, LUNG ADENOCARCINOMA
F011W05	533	8.17	0.00532	0.197	OCT-13-66	4758	0.24	FIBROSARCOMA (LIVER)
M012W05	533	11.9	0.00539	0.199	OCT-13-66	3649	0.19	UNDETERMINED (NO SKELETAL TUMOR)
M023W05	486	12.2	0.00530	0.196	MAR-21-68	5054	0.31	HEMANGIOSARCOMA (SOFT TISSUE)
M029W05	472	10.4	0.00548	0.203	MAY-08-68	2239	0.14	MELANOMA (MOUTH)
F030W05	472	10.6	0.00538	0.199	MAY-08-68	4768	0.27	PANCREATITIS
F040W05	467	9.40	0.00528	0.195	JUL-02-68	4171	0.20	MAMMARY ADENOCARCINOMA, HEMORRHAGE (LIVER)
M050W05	552	11.8	0.00526	0.195	NOV-25-69	4962	0.26	MALIGNANT MELANOMA
M059W05	496	11.5	0.00503	0.186	JAN-26-70	4566	0.23	HEPATIC CELL CARCINOMA
M063W05	485	11.4	0.00524	0.194	FEB-24-70	5421	0.30	HEMANGIOSARCOMA (SOFT TISSUE)
M070W05	497	12.8	0.00531	0.196	APR-22-70	4510	0.27	NEPHRITIS
F080W05	501	11.9	0.00545	0.202	JUL-16-70	4555	0.23	CHONDROSARCOMA, FIBROSARCOMA (SKELETON)
F081W05	501	12.1	0.00548	0.203	JUL-16-70	5306	0.30	UNDETERMINED (NO TUMOR)
F089W05	531	9.66	0.00527	0.195	AUG-25-70	4433	0.26	MAMMARY ADENOCARCINOMA
M096W05	490	12.0	0.00533	0.197	AUG-25-70	3283	0.17	INTUSSUSCEPTION
F009W10	517	8.60	0.0160	0.592	SEP-15-66	5265	0.79	CHOLANGIOCARCINOMA, SENILITY
F010W10	517	9.90	0.0162	0.599	SEP-15-66	2750	0.44	LUNG CARCINOMA
M020W10	513	10.8	0.0161	0.596	MAR-21-68	3060	0.51	LIVER MYXOSARCOMA
F021W10	513	9.36	0.0166	0.614	MAR-21-68	232	0.04	ACCIDENTAL STRANGULATION
F021W10A	552	11.4	0.0159	0.588	NOV-25-69	3262	0.57	MAST CELL SARCOMA
M022W10	486	11.6	0.0164	0.607	MAR-21-68	4793	0.88	CHONDROSARCOMA (L. RIB #10)
M028W10	472	12.1	0.0158	0.585	MAY-08-68	3632	0.56	EPIDERMOID CARCINOMA (MOUTH)
F051W10	552	8.25	0.0163	0.603	NOV-25-69	4328	0.72	DEGENERATION (KIDNEY), PNEUMONIA
M060W10	496	10.0	0.0157	0.581	JAN-26-70	4785	0.70	OSTEOSARCOMA, LUNG ADENOCARCINOMA, NEPHRITIS
M064W10	485	10.4	0.0158	0.585	FEB-24-70	3134	0.56	THROMBOEMBOLISM
F071W10	485	12.1	0.0157	0.581	APR-22-70	3891	0.58	FIBROSARCOMA (SKELETON)
M082W10	501	12.4	0.0163	0.603	JUL-16-70	4855	0.82	CHOLANGIOCARCINOMA
F090W10	526	10.9	0.0160	0.592	AUG-25-70	3998	0.63	LUNG CARCINOMA
M097W10	490	10.4	0.0160	0.592	AUG-25-70	2530	0.46	THROMBOEMBOLISM

B.1 ^{241}Am, Chronic Toxicity Study (continued)

DOG NUMBER	AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F122W10	504	9.38	0.0150	0.555	NOV-06-75	4491	0.51	PYOMETRA (UTERUS)
M123W10	516	11.8	0.0156	0.577	DEC-09-75	4607	0.62	INTERSTITIAL PNEUMONIA (LUNG)
F124W10	516	8.36	0.0157	0.581	DEC-09-75	4728	0.65	SQUAMOUS CELL CARCINOMA, ORAL MUCOSA
F127W10	494	8.89	0.0152	0.562	NOV-06-75	4683	0.57	CHOLANGIOCARCINOMA (LIVER)
M128W10	493	13.2	0.0153	0.566	NOV-06-75	4901	0.75	ANESTHETIC DEATH/RENAL DISEASE
F130W10	491	10.3	0.0153	0.566	NOV-06-75	3783	0.45	PNEUMONIA,FIBROSARC.(LIVER),MYELOPROLIFERATIVE DISEASE
M132W10	482	9.86	0.0153	0.566	NOV-06-75	4396	0.56	HEMANGIOSARCOMA, CHOLANGIOCARCINOMA (LIVER)
M134W10	489	9.03	0.0150	0.555	NOV-06-75	5093	0.79	GLOMERULONEPHRITIS;TRANSITIONAL CELL CARC., PROSTATE
F137W10	515	7.71	0.0154	0.570	DEC-09-75	5314	0.77	HEMANGIOSARCOMA, LIVER
F138W10	514	8.63	0.0152	0.562	DEC-09-75	3270	0.45	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M139W10	513	9.11	0.0157	0.581	DEC-09-75	4063	0.66	CARCINOMA (DUODENUM)
F141W10	504	8.89	0.0154	0.570	DEC-09-75	3612	0.55	MELANOMA (ORAL)
F042W17	495	9.26	0.0484	1.79	JUL-30-68	2960	1.59	MAST CELL SARCOMA (LIVER)
F043W17	492	10.4	0.0481	1.78	JUL-30-68	3666	1.82	SURGICAL COMPLICATIONS
F044W17	492	7.46	0.0473	1.75	JUL-30-68	3306	1.84	MAST CELL SARCOMA
M045W17	492	11.9	0.0486	1.80	JUL-30-68	4012	2.02	OBSTRUCTION (VENA CAVA)
M046W17	484	8.42	0.0479	1.77	JUL-30-68	2848	1.25	STATUS EPILEPTICUS
M047W17	484	11.1	0.0486	1.80	JUL-30-68	3486	1.72	HEMORRHAGE (LIVER)
F052W17	552	9.57	0.0493	1.82	NOV-25-69	4307	2.15	OSTEOSARCOMA, LUNG CARCINOMA
M061W17	496	10.7	0.0458	1.69	JAN-26-70	3767	1.70	OSTEOSARCOMA
M065W17	485	11.2	0.0471	1.74	FEB-24-70	3680	1.79	MAST CELL SARCOMA (LIVER)
F072W17	500	11.1	0.0479	1.77	APR-22-70	4293	2.13	OSTEOSARCOMA, FIBROSARCOMA (SOFT TISSUE)
M083W17	501	12.6	0.0493	1.82	JUL-16-70	3925	2.03	CHOLANGIOCARCINOMA
F091W17	490	13.3	0.0480	1.78	AUG-25-70	2193	0.94	BLOOD DYSCRASIA
M098W17	490	13.3	0.0480	1.78	AUG-25-70	3790	2.08	OSTEOSARCOMA
F115W17	502	8.73	0.0468	1.73	OCT-17-74	3942	2.17	COLLAPSED VERTEBRA, OSTEOPOROSIS
F116W17	502	8.56	0.0470	1.74	OCT-17-74	3464	2.17	OSTEOSARCOMA
F121W17	504	9.36	0.0458	1.69	NOV-06-75	2982	1.15	UNDETERMINED (NO TUMOR)
M125W17	515	10.0	0.0471	1.74	DEC-09-75	3601	1.61	OSTEOSARCOMA,CHOLANGIOCARC., HEMANGIOSARC. (LIVER)
F126W17	494	9.63	0.0456	1.69	NOV-06-75	3903	1.53	EPIDERMOID CARCINOMA, OSTEOSARCOMA
M129W17	493	8.26	0.0453	1.68	NOV-06-75	2624	1.38	OSTEOSARCOMA
F131W17	491	9.16	0.0457	1.69	NOV-06-75	4200	1.62	AORTIC BODY TUMOR
M133W17	491	10.8	0.0459	1.70	NOV-06-75	3452	1.50	UNDIFFERENTIATED SARCOMA (ILEUM, SMALL INTESTINE)
M135W17	489	10.0	0.0458	1.69	NOV-06-75	3227	1.86	OSTEOSARCOMA
F136W17	522	8.91	0.0461	1.71	DEC-09-75	1343	0.63	TRAUMA, THROMBOEMBOLISM
M140W17	513	10.5	0.0469	1.74	DEC-09-75	2691	1.33	FIBROSARCOMA (LIVER)
F007W20	560	12.6	0.0952	3.52	SEP-15-66	1847	1.67	OSTEOSARCOMA
F008W20	560	11.7	0.0957	3.54	SEP-15-66	2841	2.68	OSTEOSARCOMA
M019W20	513	13.4	0.0970	3.59	MAR-21-68	2785	2.71	FIBROSARCOMA (LIVER)
M027W20	472	12.7	0.0961	3.56	MAY-08-68	2887	2.56	MAST CELL SARCOMA
M038W20	477	9.88	0.0945	3.50	JUL-02-68	3047	3.15	OSTEOSARCOMA
F039W20	468	9.21	0.0948	3.51	JUL-02-68	3066	3.45	OSTEOSARCOMA, NOSE ADENOCARCINOMA

B.1 ^{241}Am, Chronic Toxicity Study (continued)

DOG NUMBER	AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M053W2(	498	9.24	0.0960	3.55	NOV-25-69	3055	3.21	OSTEOSARCOMA
F066W20	485	9.12	0.0935	3.46	FEB-24-70	3341	3.93	OSTEOSARCOMA
M073W20	553	14.3	0.0965	3.57	JUN-17-70	2476	2.39	COLLAPSED VERTEBRA
F084W20	493	10.6	0.0984	3.64	JUL-16-70	2773	2.93	OSTEOSARCOMA
M085W20	493	10.8	0.0987	3.65	JUL-16-70	3424	3.67	OSTEOSARCOMA, FIBROSARCOMA (LIVER)
F092W20	490	10.6	0.0962	3.56	AUG-25-70	2318	2.54	OSTEOSARCOMA
M005W30	560	15.0	0.305	11.3	SEP-15-66	1917	5.84	OSTEOSARCOMA
F006W30	560	11.9	0.310	11.5	SEP-15-66	1510	4.90	OSTEOSARCOMA
F018W30	522	8.60	0.307	11.4	MAR-21-68	1756	6.07	OSTEOSARCOMA
M026W30	472	12.4	0.310	11.5	MAY-08-68	2127	7.54	OSTEOSARCOMA, FIBROSARC.(SKELETON), HEPATIC CELL CARC.
M036W30	477	11.0	0.305	11.3	JUL-02-68	1696	5.53	OSTEOSARCOMA
F037W30	468	8.44	0.294	10.9	JUL-02-68	1764	5.29	OSTEOSARCOMA
M054W30	498	10.5	0.306	11.3	NOV-25-69	1876	7.15	OSTEOSARCOMA
M067W30	485	11.8	0.295	10.9	FEB-24-70	1883	6.67	DEGENERATION (LIVER AND KIDNEY)
F074W30	542	10.0	0.302	11.2	APR-22-70	1700	5.36	OSTEOSARCOMA
F075W30	556	9.42	0.308	11.4	JUN-17-70	1533	5.65	OSTEOSARCOMA
M086W30	493	11.3	0.312	11.5	JUL-16-70	1558	5.62	OSTEOSARCOMA
F093W30	490	11.2	0.301	11.1	AUG-25-70	1884	6.66	OSTEOSARCOMA
M100W30	542	11.0	0.304	11.2	DEC-02-70	1198	4.24	OSTEOSARCOMA
M003W40	516	12.6	0.897	33.2	JUN-28-66	1779	20.6	OSTEOSARCOMA, NEPHRITIS
F004W40	516	9.40	0.911	33.7	JUN-28-66	1533	17.7	DEGENERATION (KIDNEY AND THYROID)
M017W40	522	9.87	0.924	34.2	MAR-21-68	1132	12.6	OSTEOSARCOMA, THROMBOEMBOLISM
F025W40	472	10.5	0.927	34.3	MAY-08-68	1527	18.2	LIVER MESOTHELIOMA, DEGENERATION (KIDNEY)
M034W40	477	10.7	0.893	33.0	JUL-02-68	1566	14.8	OSTEOSARCOMA
F035W40	477	8.87	0.902	33.4	JUL-02-68	1323	15.2	HEPATIC MESOTHELIOMA
F055W40	498	8.37	0.914	33.8	NOV-25-69	1388	17.6	OSTEOSARCOMA
M068W40	485	11.8	0.890	32.9	FEB-24-70	1415	14.6	OSTEOSARCOMA
F076W40	485	9.37	0.899	33.3	APR-22-70	1569	18.0	OSTEOSARCOMA
M077W40	500	10.5	0.906	33.5	APR-22-70	633	6.98	DEGENERATION (LIVER)
M087W40	501	13.1	0.916	33.9	JUL-16-70	1300	13.9	OSTEOSARCOMA
F094W40	490	11.3	0.912	33.7	AUG-25-70	1381	15.9	OSTEOSARCOMA
M001W50	517	10.4	2.78	103.	JUN-28-66	401	14.5	DEGENERATION (LIVER AND KIDNEY)
M002W50	517	12.7	2.83	105.	JUN-28-66	448	16.0	DEGENERATION (LIVER AND KIDNEY)

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MEASUREMENTS MADE TO DATE INDICATE THE LIVER DOSE FROM AM-241 TO BE APPROXIMATELY TWO TIMES THAT TO THE SKELETON.

THE ORIGINAL "T" (TEST) DESIGNATION FOR THE ABOVE ANIMALS HAS BEEN CHANGED TO "M" AND "F" (MALE OR FEMALE) TOXICITY DESIGNATIONS. FOR EXAMPLE, THE MALE DOG ORIGINALLY INJECTED AS T001W50 IS NOW DESIGNATED M001W50.

B.2 ^{249}Cf, Chronic Toxicity Study

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F001G00	499	7.77			OCT-23-73	4481		NEPHRITIS
M002G00	509	10.5			NOV-28-72	3122		MYELOID SARCOMA
M003G00	509	10.1			NOV-28-72	4969		PNEUMONIA
F004G00	502	11.1			MAR-05-74	269		ACCIDENTAL STRANGULATION
F005G00	514	11.0			MAY-30-74	5297		HEART BLOCK/LIVER ATROPHY
M006G00	499	11.4			OCT-23-73	5873		DISC PROTRUSION; MELANOMA, ORAL
F001G01	499	9.91	.00061	0.0226	OCT-23-73	4636	0.04	MAMMARY ADENOCARCINOMA
M002G01	486	13.1	.00063	0.0233	JUL-05-72	2678	0.02	INFECTION (BACTERIAL)
M003G01	486	10.1	.00063	0.0233	JUL-05-72	3633	0.03	ANKYLOSING SPONDYLITIS
F004G01	488	11.4	.00060	0.0222	APR-24-74	5241	0.04	AXONAL DEGENERATION (BRAIN STEM)
F005G01	488	8.70	.00040	0.0222	APR-24-74	5445	0.04	MALIGNANT MELANOMA, ORAL MUCOSA
M006G01	486	11.6	.00064	0.0237	JUL-05-72	4998	0.04	MESOTHELIOMA (PLEURA)
F001G05	499	9.20	.00485	0.179	OCT-23-73	5916	0.42	PYELONEPHRITIS
M002G05	514	12.0	.00514	0.190	FEB-29-72	5105	0.38	EPIDERMOID CARCINOMA (ORAL)
M003G05	514	12.6	.00518	0.192	FEB-29-72	3668	0.26	EPIDERMOID CARCINOMA (ORAL)
F004G05	471	10.9	.00516	0.191	MAR-05-74	4208	0.36	MAMMARY ADENOCARCINOMA
F005G05	504	11.3	.00559	0.207	MAY-30-74	3788	0.33	ADENOCARCINOMA (LUNG)
M006G05	514	11.8	.00511	0.189	FEB-29-72	2037	0.16	NOSE ADENOCARCINOMA
F001G10	555	8.58	.0154	0.570	DEC-16-71	1584	0.35	STATUS EPILEPTICUS
M002G10	486	11.4	.0152	0.562	JUL-05-72	4352	0.91	CHOLANGIOCARCINOMA
M003G10	486	11.5	.0154	0.570	JUL-05-72	3849	0.82	BILIARY OBSTRUCTION
F004G10	555	10.5	.0154	0.570	DEC-16-71	4744	0.93	PNEUMONIA
F005G10	471	9.29	.0153	0.566	MAR-05-74	3063	0.54	HYDRONEPHROSIS
M006G10	524	10.6	.0160	0.592	NOV-28-72	4586	0.98	MELANOMA (MOUTH)
F001G20	558	9.32	.0905	3.35	DEC-16-71	2029	2.75	OSTEOSARCOMA
M002G20	555	11.0	.0916	3.39	DEC-16-71	2301	3.08	EPIDERMOID CARCINOMA (TYMPANIC BULLA)
M003G20	486	10.8	.0935	3.46	JUL-05-72	2618	3.28	OSTEOSARCOMA
F004G20	558	10.3	.0915	3.39	DEC-16-71	2561	3.23	OSTEOSARCOMA
F005G20	555	9.44	.0913	3.38	DEC-16-71	2821	3.63	OSTEOSARCOMA
M006G20	524	10.0	.0963	3.56	NOV-28-72	3037	4.45	OSTEOSARCOMA
F001G30	584	11.6	.290	10.7	FEB-24-71	1716	7.10	OSTEOSARCOMA
M002G30	580	13.2	.282	10.4	FEB-24-71	1770	7.22	OSTEOSARCOMA
M003G30	580	13.7	.284	10.5	FEB-24-71	1464	5.84	OSTEOSARCOMA
F004G30	580	8.79	.283	10.5	FEB-24-71	1541	6.89	OSTEOSARCOMA
F005G30	514	9.12	.300	11.1	MAY-30-74	1657	7.43	OSTEOSARCOMA
M006G30	524	10.1	.293	10.8	NOV-28-72	1322	5.97	OSTEOSARCOMA

B.3 ^{252}Cf, Chronic Toxicity Study

DOG NUMBER	AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M001F00	562	12.0			FEB-01-72	3240		FIBROSARCOMA (SOFT TISSUE)
F002F00	545	10.6			JAN-03-73	3968		MAMMARY ADENOCARCINOMA
F003F00	545	9.43			JAN-03-73	2806		EPIDERMOID CARCINOMA (NOSE)
F004F00	492	10.6			FEB-27-73	5537		PYELONEPHRITIS (KIDNEY)
M005F00	562	10.4			FEB-01-72	3720		PNEUMONIA
M006F00	509	10.9			NOV-28-72	3871		FIBROSARCOMA (SOFT TISSUE)
M001F01	498	13.0	.00060	0.0222	JUL-26-72	4054	0.02	ADENOCARCINOMA
F002F01	524	9.15	.00064	0.0237	NOV-02-72	3949	0.02	UNDETERMINED (NO TUMOR)
F003F01	545	10.1	.00075	0.0278	JAN-03-73	4542	0.03	BRONCHIOLOALVEOLAR CARCINOMA
F004F01	492	9.44	.00060	0.0222	FEB-27-73	5949	0.02	NONPRODUCTIVE OSTEOBLASTIC OSTEOSARCOMA, VERTEBRA
M005F01	498	10.4	.00060	0.0222	JUL-26-72	3581	0.02	PNEUMONIA, EMPYEMA
M006F01	524	10.3	.00062	0.0229	NOV-02-72	5115	0.03	NEPHRITIS, SENILITY
M001F05	498	12.2	.00525	0.194	JUL-26-72	5308	0.20	LYMPHOSARCOMA
F002F05	513	11.0	.00529	0.196	NOV-02-72	4318	0.20	THROMBOEMBOLISM, PNEUMONIA
F003F05	511	8.89	.00525	0.194	FEB-27-73	4567	0.19	MELANOMA (MOUTH), MAMMARY ADENOCARCINOMA
F004F05	485	11.2	.00518	0.192	FEB-27-73	4348	0.19	HEMANGIOSARCOMA (SOFT TISSUE), ADENOCARCINOMA (OVARY)
M005F05	494	9.44	.00530	0.196	JUL-26-72	4348	0.20	KIDNEY FAILURE
M006F05	524	11.0	.00529	0.196	NOV-02-72	5096	0.20	NEPHRITIS
M001F10	586	9.69	.0163	0.603	SEP-08-71	3983	0.60	FIBROSARCOMA (SOFT TISSUE)
F002F10	586	8.28	.0167	0.618	SEP-08-71	5102	0.64	MAMMARY ADENOCARCINOMA, CHOLANGIOCARCINOMA
F003F10	539	8.89	.0167	0.618	SEP-08-71	4737	0.61	KIDNEY FAILURE
F004F10	539	10.0	.0165	0.611	SEP-08-71	3652	0.60	PLASMA CELL SARCOMA, THROMBOEMBOLISM
M005F10	539	12.9	.0165	0.611	SEP-08-71	5950	0.71	LIVER ATROPHY, CHOLANGIOCARCINOMA (LIVER)
M006F10	513	9.67	.0165	0.611	NOV-02-72	4120	0.63	UNDETERMINED (NO TUMOR)
M001F20	498	11.5	.0922	3.41	JUL-26-72	2813	3.30	OSTEOSARCOMA
F002F20	545	9.85	.0905	3.35	JAN-03-73	3695	3.47	OSTEOSARCOMA
F003F20	511	9.16	.0907	3.36	FEB-27-73	3584	3.02	OSTEOSARCOMA
F004F20	473	9.33	.0910	3.37	FEB-27-73	4103	3.25	HEMANGIOSARCOMA (SOFT TISSUE)
M005F20	494	10.2	.0905	3.35	JUL-26-72	4055	3.35	MELANOMA (MOUTH)
M006F20	513	11.4	.0912	3.37	NOV-02-72	3927	3.38	FIBROSARCOMA (SKELETON)
M001F30	583	11.6	.289	10.7	MAR-03-71	1546	8.10	FIBROSARCOMA (SKELETON)
F002F30	583	10.6	.289	10.7	MAR-03-71	1723	8.14	OSTEOSARCOMA
F003F30	583	8.66	.292	10.8	MAR-03-71	2030	8.38	OSTEOSARCOMA
F004F30	583	9.69	.295	10.9	MAR-03-71	2015	8.86	OSTEOSARCOMA
M005F30	524	11.1	.284	10.5	NOV-28-72	1675	8.47	OSTEOSARCOMA
M006F30	513	10.2	.293	10.8	NOV-02-72	1846	8.57	OSTEOSARCOMA

B.4 ^{253}Es, Chronic Toxicity Study

DOG NUMBER	INJECTION: AGE (DAYS)	INJECTION: WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	INJECTION: DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F001E30	470	11.2	0.284	10.5	JUN-05-73	2586	0.15	DEGENERATION (KIDNEY), PNEUMONIA
M003E30	470	11.3	0.288	10.7	JUN-05-73	5167	0.15	UNDETERMINED
M004E30	470	7.93	0.294	10.9	JUN-05-73	4694	0.16	PNEUMONIA, HYPOTHYROIDISM
F001E50	495	8.70	2.85	5.45	JUN-05-73	2876	1.46	MAST CELL SARCOMA
F002E50G	483	9.21	2.81	104.	JUN-05-73	2009	7.53	OSTEOSARCOMA
M003E50	470	10.4	2.84	105.	JUN-05-73	4762	1.50	LUNG CARCINOMA

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F002E50G SUBSEQUENTLY RECEIVED 11.8 KBQ/KG (0.318 UCI/KG) OF CF-249 ON MAY 28, 1974, 7.34 OF THE TOTAL 7.53 GY WERE FROM CF-249.

B.5 ^{239}Pu, Chronic Toxicity Study

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M001P00	442	9.70			DEC-01-52	4003		RUPTURE (SPLEEN),SEMINOMA
F002P00	424	6.36			MAR-02-53	2755		ANESTHETIC ACCIDENT
M003P00	515	10.8			JUN-01-53	5362		PANCREAS ADENOCARCINOMA
M004P00	426	10.7			SEP-16-53	5138		THYROID ADENOCARCINOMA,NEPHRITIS
F005P00	620	9.75			OCT-14-53	4088		ADRENAL CORTEX ADENOCARCINOMA
F006P00	409	5.59			MAY-12-54	4490		THROMBOEMBOLISM
F007P00	515	6.90			OCT-25-54	5344		RHABDOMYOSARCOMA, MAMMARY ADENOCARCINOMA
M008P00	584	10.9			MAR-15-55	4072		CIRCULATORY FAILURE
F009P00	573	11.0			SEP-09-55	3032		THROMBOEMBOLISM,NEPHRITIS
F010P00	658	11.0			NOV-22-55	3971		LYMPHOSARCOMA
M011P00	602	10.3			APR-24-56	3821		FIBROSARCOMA (SOFT TISSUE)
M012P00	630	10.9			MAY-29-56	4143		CARCINOMA (TESTES), HEMANGIOSARCOMA (SPLEEN)
F013P00	516	9.47			MAR-04-64	5361		OSTEOSARCOMA
F014P00	452	9.89			MAY-12-64	4105		ENDOMETRITIS
M015P00	526	12.1			OCT-23-64	3750		TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M016P00	486	13.9			APR-07-65	4756		SENILITY
M017P00	551	12.2			NOV-08-66	5535		SENILITY THROMBOEMBOLISM, MELANOMA (EYE AND ORAL)
F018P00	536	11.4			NOV-29-66	4849		NEPHRITIS
M019P00	536	13.1			NOV-29-66	5203		FIBROSARCOMA (TURBINATES)
F020P00	546	8.50			DEC-29-66	3748		PLEURAL EFFUSION
M021P00	549	13.3			JAN-26-67	4157		AORTIC BODY TUMOR
F022P00	489	10.6			MAY-25-67	4403		NEPHRITIS
M031P00B	452	11.8			MAY-12-64	1763		STATUS EPILEPTICUS,BILIARY OBSTRUCTION
M031P00C	452	12.6			MAY-12-64	3629		MELANOMA (MOUTH)
M032P00B	452	11.2			MAY-12-64	4840		CARDIAC INSUFFICIENCY
M032P00C	542	10.3			SEP-21-65	5046		SENILITY
M033P00B	516	12.1			SEP-21-65	4923		SENILITY
M033P00C	503	11.7			NOV-18-65	4164		INANITION,UNDETERMINED (NO SKELETAL TUMOR)
M034P00B	524	13.5			JAN-26-67	5487		MELANOMA (MOUTH),NEPHRITIS
M034P00C	484	12.7			MAR-22-67	4139		INANITION,UNDETERMINED (NO SKELETAL TUMOR)
M035P00B	484	12.5			MAR-22-67	5654		ASTROCYTOMA
M035P00C	484	13.1			MAR-22-67	3501		PARALYSIS (NO SKELETAL TUMOR)
M036P00B	489	11.0			MAY-25-67	2525		STATUS EPILEPTICUS
M036P00C	485	12.2			MAY-25-67	5244		DEGENERATION (KIDNEY),FASCIITIS
M037P00B	507	11.7			JUN-22-67	4179		INANITION,UNDETERMINED (NO SKELETAL TUMOR)
M037P00C	493	10.4			JUN-22-67	4485		PANCREATITIS
M038P00B	529	10.7			NOV-16-67	3623		TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M038P00C	529	12.2			NOV-16-67	3382		PNEUMONIA
M039P00B	502	10.7			DEC-21-67	6061		CARCINOMA (AORTIC BODY,PROSTATE),SENILITY
M039P00C	502	10.1			DEC-21-67	5113		PNEUMONIA
M040P00B	484	10.3			JUL-30-68	4957		PANCREAS ADENOCARCINOMA,SEMINOMA
M040P00C	552	11.4			JAN-09-69	3377		PERIARTERITIS

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M041P00B	560	9.49			JAN-17-69	3875		PANCREATITIS
M042P00	479	14.0			APR-24-74	3242		LYMPHOSARCOMA
M043P00	479	13.8			APR-24-74	4216		INTESTINAL CARCINOMA,BILIARY OBSTRUCTION
M044P00	479	12.7			APR-24-74	4648		PNEUMONIA
M045P00	497	11.5			AUG-29-74	1537		STATUS EPILEPTICUS
M046P00	497	11.5			AUG-29-74	5584		TRANSITIONAL CELL CARCINOMA, BLADDER
M047P00	497	11.3			AUG-29-74	3715		LYMPHOSARCOMA
M048P00	497	11.7			AUG-29-74	5983		HYDROCEPHALUS
M081P00Y	97	7.10			MAR-01-72	5718		HYPOTHERMIA,BRONCHIOLOALVEOLAR CARCINOMA (LUNG)
F082P00Y	97	7.30			MAR-01-72	4547		ENDOMETRITIS,PANCREATITIS
F083P00Y	91	3.97			APR-25-72	4696		PERFORATION (INTESTINE)
F084P00Y	89	3.67			APR-25-72	5202		MELANOMA (ORAL)
M086P00Y	91	4.37			APR-25-72	5381		UNDETERMINED (NO SKELETAL TUMOR)
F101P00Y								REASSIGNED,SEE F511R40+
M102P00Y								REASSIGNED,SEE M512R40+
F103P00Y								REASSIGNED,SEE T240P30+
M104P00Y								REASSIGNED,SEE T241P30+
M105P00Y	92	4.90			APR-27-76	1353		ACCIDENTAL STRANGULATION
F106P00Y								REASSIGNED,SEE T247P30+
M107P00Y	90	4.07			APR-27-76	2660		THROMBOEMBOLISM
F108P00Y								REASSIGNED,SEE T251P30+
M109P00Y	91	4.08			DEC-16-76	2736		STATUS EPILEPTICUS
F013P01	515	9.46	0.00068	0.0252	MAR-04-64	4492	0.02	TRANSITIONAL CELL CARC.(URINARY BLADDER),PERITONITIS
F014P01	452	10.3	0.00055	0.0204	MAY-12-64	4503	0.02	CHONDROSARCOMA (HUMERUS)
M015P01	536	9.67	0.00071	0.0263	OCT-23-64	4319	0.02	PANCREATIC DYSTROPHY
M016P01	501	12.0	0.00059	0.0218	APR-07-65	4146	0.02	EPIDERMOID CARC.(FRONTAL SINUS),SCIRRHOUS ADENOCARC.
M017P01	551	12.2	0.00057	0.0211	NOV-08-66	4346	0.02	LYMPHOSARCOMA
F018P01	536	9.28	0.00070	0.0259	NOV-29-66	4221	0.02	MELANOMA (MOUTH)
M019P01	536	11.6	0.00063	0.0233	NOV-29-66	5519	0.02	NEPHRITIS
F020P01	536	9.80	0.00075	0.0278	DEC-29-66	3939	0.02	MAMMARY ADENOCARCINOMA
M021P01	538	11.3	0.00059	0.0218	JAN-26-67	4676	0.02	LUNG CARCINOMA
F022P01	489	9.80	0.00059	0.0218	MAY-25-67	2968	0.01	ACCIDENTAL STRANGULATION
M031P01B	516	12.2	0.00068	0.0252	MAR-04-64	2760	0.01	STATUS EPILEPTICUS
F032P01B	549	10.4	0.00059	0.0218	NOV-18-65	5272	0.02	TRANS. CELL CARC.(URIN. BLADDER)GRANULOSA CELL TUMOR
M033P01B	549	10.8	0.00079	0.0292	NOV-18-65	4156	0.02	BONE MARROW APLASIA
F034P01B	533	11.1	0.00058	0.0215	NOV-08-66	3292	0.01	PANCREATITIS
M035P01B	489	10.3	0.00059	0.0218	MAY-25-67	5036	0.02	UNDIFFERENTIATED MALIGNANCY (ABDOMEN)
F036P01B	493	9.79	0.00060	0.0222	JUN-22-67	3600	0.02	PNEUMONIA
M037P01B	493	11.3	0.00059	0.0218	JUN-22-67	5072	0.02	ANKYLOSING SPONDYLITIS
F038P01B	513	9.52	0.00057	0.0211	DEC-21-67	1979	0.01	TRAUMA
M039P01B	490	10.5	0.00058	0.0215	DEC-21-67	4466	0.02	HEMANGIOSARCOMA (SOFT TISSUE)
M044P01B	500	10.9	0.00057	0.0211	AUG-08-73	4412	0.02	NEPHRITIS
F044P01C	569	8.34	0.00072	0.0266	DEC-02-70	4025	0.02	PULMONARY EMBOLISM, NEPHRITIS

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M045P01B	504	13.5	0.00122	0.0451	MAY-30-74	3762	0.03	KIDNEY FAILURE,PNEUMONIA
F045P01C	500	9.00	0.00051	0.0189	AUG-08-73	5517	0.02	ABCESSATION (TOOTH)
M046P01B	504	13.2	0.00120	0.0444	MAY-30-74	3630	0.03	OBSTRUCTION (INTESTINE)
F046P01C	500	10.2	0.00057	0.0211	AUG-08-73	4409	0.02	ENDOMETRITIS,PERITONITIS
F047P01	500	9.34	0.00051	0.0189	AUG-08-73	4507	0.02	HEMANGIOSARCOMA (SOFT TISSUE)
F048P01	527	10.9	0.00120	0.0444	MAY-30-74	4858	0.04	PNEUMONIA (LUNG)
F049P01	504	9.71	0.00124	0.0459	MAY-30-74	3222	0.03	NEPHRITIS
F013P02	516	9.44	0.00206	0.0762	MAR-04-64	3221	0.05	ILEUS (INTESTINE), PANCREATITIS
F014P02	516	7.44	0.00173	0.0640	MAY-12-64	3983	0.05	ENTERITIS, NEPHRITIS
M015P02	505	10.9	0.00201	0.0744	OCT-23-64	4803	0.07	ATHEROSCLEROSIS, ARTERIOSCLEROSIS
M016P02	500	11.4	0.00163	0.0603	APR-07-65	2841	0.04	ENCEPHALITIS
M017P02	533	11.8	0.00171	0.0633	NOV-08-66	4391	0.05	LYMPHOSARCOMA
F018P02	530	9.46	0.00200	0.0740	NOV-29-66	5319	0.07	NEPHRITIS
M019P02	530	12.1	0.00198	0.0733	NOV-29-66	4392	0.06	UNDETERMINED (NO SKELETAL TUMOR)
F020P02	532	8.30	0.00224	0.0829	DEC-29-66	4299	0.07	THROMBOEMBOLISM
M021P02	538	12.1	0.00181	0.0670	JAN-26-67	4708	0.06	UNDETERMINED (NO TUMOR)
F022P02	485	8.30	0.00176	0.0651	MAY-25-67	4080	0.05	LYMPHOSARCOMA
M031P02B	515	10.7	0.00185	0.0685	MAR-04-64	2640	0.04	MELANOMA (MOUTH)
F031P02C	452	11.9	0.00169	0.0625	MAY-12-64	4971	0.06	THROMBOEMBOLISM
F031P02D	428	9.35	0.00186	0.0688	MAY-12-64	5378	0.07	METASTATIC MAST CELL TUMORS
M032P02B	549	13.6	0.00178	0.0659	NOV-18-65	3591	0.05	HEMANGIOSARCOMA (SOFT TISSUE)
F032P02C	494	10.1	0.00183	0.0677	FEB-04-65	3881	0.05	MAMMARY ADENOCARCINOMA,THROMBOEMBOLISM
F032P02D	490	8.04	0.00193	0.0714	FEB-04-65	5241	0.07	MAST CELL SARCOMA
M033P02B	513	14.5	0.00178	0.0659	NOV-18-65	2776	0.04	PNEUMONIA
F033P02C	549	12.5	0.00176	0.0651	NOV-18-65	4615	0.06	HEMORRHAGE (KIDNEY)
F033P02D	513	12.7	0.00178	0.0659	NOV-18-65	5068	0.06	RHABDOMYOSARCOMA
M034P02B	533	12.7	0.00170	0.0629	NOV-08-66	3934	0.05	PROSTATE ADENOCARCINOMA
F034P02C	533	11.5	0.00172	0.0636	NOV-08-66	4515	0.05	LUNG CARCINOMA
F034P02D	519	9.92	0.00167	0.0618	NOV-08-66	4552	0.05	NEPHRITIS
M035P02B	489	11.2	0.00173	0.0640	MAY-25-67	4359	0.05	LYMPHOSARCOMA, ENTERITIS, INANITION
F035P02C	507	10.5	0.00175	0.0648	JUN-22-67	2593	0.04	LUNG CARCINOMA
F035P02D	507	9.10	0.00175	0.0648	JUN-22-67	4330	0.05	ENDOMETRITIS,PERITONITIS,NEPHRITIS
M036P02B	479	12.9	0.00177	0.0655	MAY-25-67	5245	0.06	MYXOSARCOMA (LIVER)
F036P02C	493	10.4	0.00177	0.0655	JUN-22-67	3291	0.04	ENTERITIS
F036P02D	569	8.74	0.00146	0.0540	NOV-16-67	3351	0.04	LYMPHOSARCOMA, PERFORATION (INTESTINE)
M037P02B	529	10.6	0.00149	0.0551	NOV-16-67	2804	0.03	HEMANGIOSARCOMA (SOFT TISSUE)
F037P02C	529	10.1	0.00150	0.0555	NOV-16-67	4829	0.05	PNEUMONIA
F037P02D	529	7.14	0.00153	0.0566	NOV-16-67	4787	0.05	MAMMARY ADENOCARCINOMA
M038P02B	517	10.0	0.00152	0.0562	NOV-16-67	3546	0.04	PLASMA CELL SARCOMA (SOFT TISSUE & SKELETON)
F038P02C	502	7.95	0.00211	0.0781	DEC-21-67	5006	0.07	DEGENERATION (LIVER),MAMMARY ADENOCARCINOMA
F038P02D	498	9.08	0.00176	0.0651	DEC-21-67	2880	0.04	NEPHRITIS,PANCREATITIS
M039P02B	542	11.6	0.00214	0.0792	DEC-02-70	2916	0.05	HEMANGIOSARCOMA (SOFT TISSUE)
F039P02C	498	9.46	0.00173	0.0640	DEC-21-67	4911	0.06	HEPATIC CELL CARCINOMA

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F039P02D	498	9.34	0.00176	0.0651	DEC-21-67	3401	0.05	RHABDOMYOSARCOMA
M042P02B	504	9.42	0.00182	0.0673	AUG-08-73	4752	0.06	CHRONIC INTERSTITIAL NEPHRITIS
F042P02C	589	9.55	0.00176	0.0651	SEP-04-69	3966	0.05	OSTEOSARCOMA,VAGINA ADENOCARCINOMA
M043P02B	497	11.0	0.00179	0.0662	APR-24-74	4620	0.06	ADENOCARCINOMA (NASAL) TRACHEITIS
F043P02C	542	9.50	0.00239	0.0884	DEC-02-70	4942	0.08	MAMMARY ADENOCARCINOMA
M044P02B	540	11.6	0.00177	0.0655	NOV-17-71	97	0.01	SPECIAL STUDY
M044P02C	491	12.0	0.00188	0.0696	APR-24-74	5069	0.07	MELANOMA (ORAL CAVITY)
M044P02D	488	11.6	0.00184	0.0681	APR-24-74	4457	0.06	KIDNEY FAILURE,ADRENAL HYPOPLASIA
M045P02B	488	11.6	0.00184	0.0681	APR-24-74	3631	0.05	PARALYSIS (CERVICAL SPONDYLOSIS)
M045P02C	482	11.4	0.00188	0.0696	APR-24-74	5735	0.07	GLOMERULONEPHRITIS
M046P02B	482	11.1	0.00179	0.0662	APR-24-74	2624	0.04	UNDIFFERENTIATED MALIGNANCY (SOFT TISSUE)
F013P05	516	9.93	0.00540	0.200	MAR-04-64	2388	0.11	MAMMARY ADENOCARCINOMA
F013P05A	501	11.2	0.00495	0.183	SEP-23-70	3498	0.13	MAMMARY ADENOCARCINOMA
F014P05	516	9.98	0.00493	0.182	MAY-12-64	4537	0.16	CHONDROSARCOMA (TURBINATES + HUMERUS)
M015P05	505	8.41	0.00627	0.232	OCT-23-64	4588	0.20	THROMBOEMBOLISM,THYROID CARCINOMA
M016P05	501	12.6	0.00521	0.193	APR-07-65	4062	0.15	CHROMOPHOBE ADENOMA
M017P05	533	13.4	0.00506	0.187	NOV-08-66	4564	0.16	ANKYLOSIING SPONDYLITIS
F018P05	530	8.98	0.00594	0.220	NOV-29-66	4333	0.18	HEMANGIOSARCOMA (SOFT TISSUE)
M019P05	530	11.9	0.00645	0.239	NOV-29-66	3829	0.18	OSTEOSARCOMA
F020P05	532	9.30	0.00553	0.205	DEC-29-66	3490	0.14	EPIDERMOID CARCINOMA (MOUTH)
M021P05	538	9.80	0.00526	0.195	JAN-26-67	4954	0.18	DEGENERATION (KIDNEY),HEMORRHAGE (HYPOTHALAMUS)
F022P05	485	8.10	0.00525	0.194	MAY-25-67	5203	0.19	ANKYLOSING SPONDYLITIS,PNEUMONIA
M025P05	509	9.70	0.00539	0.199	JAN-30-74	4807	0.18	CHROMOPHOBE ADENOMA,SENILITY
M026P05	509	9.96	0.00536	0.198	JAN-30-74	4062	0.16	PNEUMONIA
M031P05B	515	10.5	0.00549	0.203	MAR-04-64	1648	0.08	STATUS EPILEPTICUS
F031P05C	494	8.44	0.00572	0.212	FEB-04-65	2546	0.12	SPECIAL STUDY
M032P05B	549	13.6	0.00546	0.202	NOV-18-65	2275	0.10	SPECIAL STUDY
F033P05B	503	10.1	0.00559	0.207	NOV-18-65	4509	0.18	MAMMARY CARCINOMA
M034P05B	530	12.5	0.00642	0.238	NOV-29-66	1981	0.11	SPECIAL STUDY
F035P05B	501	9.54	0.00520	0.192	JUN-22-67	4502	0.17	LUNG CARCINOMA
M036P05B	479	11.5	0.00527	0.195	MAY-25-67	3885	0.15	OSTEOSARCOMA
F037P05B	517	8.39	0.00454	0.168	NOV-16-67	4956	0.16	EPIDERMOID CARCINOMA (MOUTH)
M038P05B	517	10.5	0.00448	0.166	NOV-16-67	3498	0.12	UNDETERMINED (NO SKELETAL TUMOR)
F039P05B	490	10.9	0.00528	0.1951	DEC-21-67	4350	0.16	PERITONITIS,MAMMARY CARCINOMA
M042P05B	542	13.1	0.00675	0.250	DEC-02-70	4194	0.20	INANITION
M042P05C	542	12.2	0.00668	0.247	DEC-02-70	4778	0.22	PNEUMONIA
F042P05D	542	9.71	0.00668	0.247	DEC-02-70	3618	0.18	SURGICAL COMPLICATIONS
F043P05B	545	11.6	0.00484	0.179	OCT-03-69	4177	0.15	ENDOMETRITIS
F043P05C	537	10.7	0.00480	0.178	OCT-03-69	4393	0.15	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M043P05D	500	12.0	0.00546	0.202	AUG-08-73	5690	0.21	CHRONIC INTERSTITIAL PNEUMONIA
M044P05B	445	11.5	0.00360	0.133	JUN-03-69	99	0.01	SPECIAL STUDY
F044P05C	504	8.48	0.00604	0.223	AUG-08-73	4279	0.18	LUNG ABSCESS,LIVER DEGENERATION
M045P05B	472	10.3	0.00350	0.130	JUN-03-69	42	0.01	SPECIAL STUDY

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	AGE (DAYS)	WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F045P05C	540	10.0	0.00516	0.191	NOV-17-71	35	0.01	SPECIAL STUDY
M046P05B	484	11.8	0.00336	0.124	JUN-03-69	7	0.01	SPECIAL STUDY
F046P05C	540	9.15	0.00516	0.191	NOV-17-71	7	0.01	SPECIAL STUDY
M047P05	568	11.9	0.00524	0.194	AUG-08-74	2302	0.10	ABSCESS (LUNG),EMPYEMA
M048P05	568	12.1	0.00546	0.202	AUG-08-74	4809	0.18	INTERVERTEBRAL DISC PROLAPSE
F049P05	569	9.10	0.00537	0.199	AUG-08-74	3240	0.13	ENDOMETRITIS
F050P05	568	12.8	0.00541	0.200	AUG-08-74	4576	0.17	KIDNEY FAILURE
M051P05	506	11.9	0.00552	0.204	AUG-29-74	4272	0.17	THROMBOEMBOLISM (PORTAL VEIN)
M052P05	506	10.4	0.00549	0.203	AUG-29-74	3205	0.13	FIBROSARCOMA (SOFT TISSUE)
M053P05	498	13.2	0.00515	0.191	AUG-29-74	4004	0.15	OSTEOSARCOMA
M054P05	497	10.8	0.00551	0.204	AUG-29-74	2478	0.11	PNEUMONIA,EMPYEMA
F055P05	533	9.65	0.00547	0.202	OCT-17-74	2943	0.13	ACUTE PNEUMONITIS
F056P05	533	9.56	0.00552	0.204	OCT-17-74	2917	0.13	INANITION
F057P05	523	8.14	0.00524	0.194	OCT-17-74	4166	0.16	AORTIC BODY CARCINOMA,DEGENERATION (LIVER)
F101P05Y	93	2.74	0.00617	0.228	SEP-19-74	4207	0.13	ADENOCARCINOMA
M102P05Y	91	3.43	0.00618	0.229	SEP-19-74	5796	0.18	NEPHROSCLEROSIS; CHOLANGIOCARCINOMA, LIVER
F103P05Y	91	3.39	0.00611	0.226	SEP-19-74	4815	0.15	INANITION
M104P05Y	90	3.43	0.00525	0.194	APR-27-76	4222	0.11	AMYLOIDOSIS (KIDNEY),ADENOCARCINOMA (PITUITARY)
M105P05Y	89	4.17	0.00570	0.211	NOV-26-74	2787	0.08	ENTERITIS
F106P05Y	89	4.51	0.00580	0.215	NOV-26-74	4284	0.12	GRANULOSA CELL CARCINOMA
F107P05Y	94	3.53	0.00553	0.205	SEP-22-76	5584	0.15	CARCINOMA, MAMMARY GLAND
M108P05Y	91	4.47	0.00484	0.179	DEC-16-76	1793	0.05	DEGENERATION (PANCREAS)
F109P05Y	88	3.95	0.00542	0.201	APR-20-78	5339	0.14	HEMANGIOSARCOMA,SPLEEN
M110P05Y	90	4.48	0.00521	0.193	MAR-09-78	4863	0.13	LYMPHOSARCOMA
F111P05Y	88	3.67	0.00533	0.197	MAY-23-78	5412	0.14	MELANOMA,MOUTH
F014P07	533	8.98	0.00947	0.350	JUL-22-69	4746	0.31	PNEUMONIA
M015P07	533	10.3	0.00941	0.348	JUL-22-69	3471	0.24	CHONDROSARCOMA (SKELETAL,TURBINATES)
M016P07	516	11.9	0.0102	0.377	SEP-04-69	3573	0.27	HEPATITIS
M017P07	540	8.04	0.0103	0.381	OCT-03-69	3938	0.30	TRANSITIONAL CELL CARCINOMA, CHROMOPHOBE ADENOMA
F018P07	531	9.66	0.00942	0.349	JUL-22-69	4823	0.32	NEPHRITIS,DEGENERATION (LIVER)
M019P07	501	11.6	0.0104	0.385	SEP-23-70	1737	0.16	STRANGULATED HERNIA
F020P07	521	9.18	0.00926	0.343	JUL-22-69	3718	0.25	FIBROSARCOMA (LIVER)
M021P07	499	11.1	0.0104	0.385	SEP-23-70	5212	0.37	GLAUCOMA,SENILITY
F022P07	538	9.69	0.0108	0.400	SEP-04-69	4657	0.35	UNDETERMINED (NO TUMOR)
F023P07	538	9.56	0.0108	0.400	SEP-04-69	4481	0.34	OSTEOSARCOMA,PNEUMONIA
F024P07	516	8.90	0.0110	0.407	SEP-04-69	3861	0.31	OSTEOSARCOMA
M025P07	506	10.9	0.0117	0.433	AUG-08-73	2042	0.20	STATUS EPILEPTICUS
M026P07	494	10.2	0.0112	0.414	SEP-20-73	4023	0.33	OSTEOSARCOMA
M027P07	494	11.9	0.0116	0.429	SEP-20-73	5598	0.44	CHRONIC INTERSTITIAL NEPHRITIS/BRONCHIOLOALVEOLAR CARC
F028P07	494	10.6	0.0110	0.407	SEP-20-73	4512	0.35	BILIARY OBSTRUCTION,SUPPURATIVE CHOLANGIOHEPATITIS
F029P07	493	8.63	0.0113	0.418	SEP-20-73	4210	0.34	PHEOCHROMOCYTOMA
F030P07	487	9.91	0.0113	0.418	SEP-20-73	4246	0.34	OSTEOSARCOMA,MYELOPROLIFERATIVE DISEASE
M031P07	521	13.2	0.00956	0.354	DEC-04-73	4253	0.29	LYMPHOSARCOMA

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M032P07	521	9.46	0.00967	0.358	DEC-04-73	3496	0.25	PROSTATITIS,PERITONITIS
M033P07	509	10.7	0.0103	0.381	JAN-30-74	4807	0.35	KIDNEY FAILURE,PNEUMONIA
M034P07	521	10.1	0.00979	0.362	DEC-04-73	3711	0.27	THROMBOEMBOLISM
F035P07	521	10.6	0.00981	0.363	DEC-04-73	3661	0.27	PANCREATITIS,DIABETES MELLITUS
F036P07	521	11.1	0.00999	0.370	DEC-04-73	3951	0.29	PANCREATITIS
M037P07	520	11.6	0.00999	0.370	DEC-04-73	2836	0.22	FIBROSIS (LUNG),HEMANGIOSARCOMA (SOFT TISSUE)
F038P07	520	11.4	0.00995	0.368	DEC-04-73	4235	0.30	UNDETERMINED (NO SKELETAL TUMOR)
F039P07	512	8.24	0.00969	0.359	DEC-04-73	4795	0.32	KIDNEY FAILURE
M040P07	512	10.7	0.00990	0.366	DEC-04-73	4074	0.29	ADENOCARCINOMA (RECTUM)
M041P07	533	11.9	0.0105	0.389	JAN-30-74	2750	0.23	DEGENERATION (KIDNEY)
M042P07	533	11.6	0.0106	0.392	JAN-30-74	4235	0.32	THROMBOEMBOLISM
M043P07	533	10.1	0.0106	0.392	JAN-30-74	4942	0.36	OSTEOSARCOMA,CARCINOMA (LUNG)
F044P07	533	10.2	0.0105	0.389	JAN-30-74	4285	0.32	AMYLOID.(KID.),TR. CELL CARC.(BLADDER),THY. ADENOCARC.
M045P07	509	10.8	0.0104	0.385	JAN-30-74	4362	0.32	OSTEOSARCOMA,SEMINOMA
F046P07	509	10.2	0.0105	0.389	JAN-30-74	4655	0.34	TRANSITIONAL CELL CARCINOMA
F047P07	508	8.39	0.0103	0.381	JAN-30-74	5422	0.38	CHRONIC INTERSTITIAL NEPHRITIS/CELLULITIS
M048P07	502	10.3	0.00910	0.337	MAR-05-74	4735	0.30	PNEUMONIA
M049P07	471	12.3	0.00990	0.366	MAR-05-74	3405	0.25	UNDETERMINED (NO TUMOR)
F050P07	522	9.33	0.0112	0.414	AUG-29-74	4030	0.33	OSTEOSARCOMA
F051P07	522	11.8	0.0105	0.389	AUG-29-74	5594	0.40	HEPATIC NECROSIS AND REGENERATION
M001P10	442	9.41	0.0150	0.555	DEC-01-52	4572	0.48	OSTEOSARCOMA
F002P10	422	6.85	0.0163	0.603	MAR-02-53	4810	0.55	HEPATIC CELL CARCINOMA
M003P10	515	8.00	0.0165	0.611	JUN-01-53	4292	0.51	OSTEOSARCOMA
M004P10	608	9.97	0.0139	0.514	SEP-16-53	4549	0.45	CHOLANGIOCARCINOMA
F005P10	620	8.80	0.0142	0.525	OCT-14-53	1539	0.20	COLITIS,ENTERITIS,DEGENERATION (LIVER)
F005P10A	472	11.0	0.0168	0.622	SEP-03-58	3764	0.47	THYROID CARCINOMA
F006P10	409	7.38	0.0140	0.518	MAY-12-54	4292	0.43	COLON CARCINOMA
F007P10	510	6.36	0.0167	0.618	OCT-25-54	3981	0.48	TRAUMA,LYMPHADENOPATHY
M008P10	453	10.6	0.0172	0.636	MAR-15-55	3367	0.44	OSTEOSARCOMA
F009P10	555	7.87	0.0168	0.622	SEP-09-55	2257	0.32	OSTEOSARCOMA
F010P10	641	12.0	0.0152	0.562	NOV-22-55	3649	0.41	MAMMARY ADENOCARCINOMA
M011P10	602	8.90	0.0157	0.581	APR-24-56	5161	0.56	THYROID CARCINOMA
M012P10	629	9.67	0.0167	0.618	MAY-29-56	2374	0.33	PANCREATITIS
M013P10	504	12.7	0.0153	0.566	SEP-03-58	5277	0.55	SENILITY,HYDROCEPHALUS
F014P10	533	10.4	0.0141	0.522	JUL-22-69	4185	0.42	SURGICAL COMPLICATIONS
M015P10	516	12.8	0.0159	0.588	SEP-04-69	3596	0.42	MELANOMA (MOUTH)
M016P10	516	10.6	0.0165	0.611	SEP-04-69	4211	0.50	OSTEOSARCOMA
M017P10	537	10.9	0.0151	0.559	OCT-03-69	4690	0.50	CHONDROSARCOMA (TURBINATES)
F018P10	531	9.89	0.0140	0.518	JUL-22-69	4788	0.47	OVARY ADENOCARCINOMA
M019P10	501	9.82	0.0159	0.588	SEP-23-70	5217	0.57	CARCINOMA (SERT. CELLS)
F020P10	521	10.4	0.0141	0.522	JUL-22-69	3482	0.37	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M021P10	499	10.0	0.0156	0.577	SEP-23-70	3734	0.43	OSTEOSARCOMA
F022P10	521	9.04	0.0139	0.514	JUL-22-69	4035	0.41	OSTEOSARCOMA

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F023P10	538	11.2	0.0163	0.603	SEP-04-69	4508	0.52	CHROMOPHOBE ADENOMA
F024P10	516	10.4	0.0163	0.603	SEP-04-69	3308	0.41	OSTEOSARCOMA
M025P10	504	11.0	0.0168	0.622	AUG-08-73	4793	0.56	HEMANGIOSARCOMA (NON-SKELETAL)
F101P10Y	93	2.23	0.0171	0.633	SEP-19-74	4636	0.39	THROMBOEMBOLISM (PULMONARY)
M102P10Y	91	2.83	0.0171	0.633	SEP-19-74	3549	0.31	PARALYSIS (SPONDYLITIS)
F103P10Y	89	3.56	0.0137	0.507	NOV-21-74	1929	0.14	PERSISTENT AORTIC ARCH
M104P10Y	89	5.14	0.0158	0.585	NOV-21-74	3789	0.30	THROMBOEMBOLISM
M105P10Y	91	5.19	0.0143	0.529	MAR-02-76	4143	0.30	RHABDOMYOSARCOMA
F106P10Y	91	4.36	0.0142	0.525	MAR-02-76	5417	0.38	CARCINOMA,PITUITARY
F107P10Y	92	4.46	0.0194	0.718	OCT-08-76	5333	0.51	BILIARY CYSTS
F108P10Y	90	2.52	0.0146	0.540	DEC-16-76	5839	0.42	CARCINOMA,THYROID
M109P10Y	90	3.78	0.0155	0.574	MAR-09-78	4918	0.38	MAST CELL TUMOR,SKIN
M110P10Y	88	3.77	0.0158	0.585	MAY-23-78	4950	0.39	MALIGNANT MELANOMA
F501P10+	1787	9.54	0.0158	0.585	JUN-10-75	3752	0.42	FIBROSARC.(SOFT TIS),MAMM. ADENOCARC. CHOLANGIOCARC.
F502P10+	1830	11.4	0.0174	0.644	JUL-06-77	2990	0.40	OSTEOSARCOMA,FIBROSARCOMA (SKELETON)
F503P10+	1855	9.76	0.0163	0.603	MAY-09-78	3381	0.40	FIBROSARCOMA (ORAL)
M507P10+	1481	13.3	0.0158	0.585	MAY-09-78	4028	0.44	CHOLANGIOCARCINOMA
M001P17	657	8.72	0.0475	1.76	JUN-26-56	3025	1.11	OSTEOSARCOMA
F002P17	527	8.62	0.0431	1.59	NOV-22-55	3430	1.11	OSTEOSARCOMA
M003P17	642	8.63	0.0495	1.83	JUN-26-56	3430	1.28	CHROMOPHOBE CARC.,BIL. OBSTRUCTION,PROS. ADENOCARC.
M004P17	673	8.37	0.0484	1.79	OCT-10-56	3312	1.22	OSTEOSARCOMA
F005P17	642	11.6	0.0493	1.82	JUN-26-56	2659	1.05	OSTEOSARCOMA
F006P17	642	10.3	0.0459	1.70	JUN-26-56	2221	0.86	OSTEOSARCOMA
F007P17	756	9.73	0.0481	1.78	OCT-10-56	3353	1.22	CHONDROSARCOMA
M008P17	673	13.6	0.0479	1.77	OCT-10-56	3282	1.19	OSTEOSARCOMA
F009P17	756	9.72	0.0485	1.79	OCT-10-56	2500	0.99	OSTEOSARCOMA
F010P17	739	10.6	0.0495	1.83	OCT-10-56	467	0.27	ENTERITIS
F010P17A	472	8.07	0.0457	1.69	SEP-03-58	4214	1.38	OSTEOSARCOMA
M011P17	599	11.6	0.0486	1.80	APR-24-56	2777	1.07	CHOLANGIOCARCINOMA
M012P17	673	9.41	0.0491	1.82	OCT-10-56	2973	1.14	LYMPHOSARCOMA
M013P17	504	10.6	0.0473	1.75	SEP-03-58	4375	1.47	CHONDROSARCOMA, OSTEOSARCOMA
F101P17Y	93	2.34	0.0543	2.01	SEP-19-74	4834	1.30	CARDIOMYOPATHY (HEART),CHOLANGIOCARCINOMA (LIVER)
M102P17Y	91	2.97	0.0545	2.02	SEP-19-74	3604	0.99	HEPATITIS
F103P17Y	89	3.84	0.0453	1.68	NOV-21-74	3912	0.89	TRANSITIONAL CELL CARC.(URINARY BLADDER),NEPHROSIS
M104P17Y	93	3.40	0.0488	1.81	APR-27-76	5635	1.35	ADENOMA, PITUITARY
M105P17Y	90	4.06	0.0485	1.79	APR-27-76	4014	0.97	THROMBOEMBOLISM (AORTA)
F106P17Y	89	4.20	0.0529	1.96	NOV-26-74	3885	1.03	OSTEOSARCOMA,CHOLANGIOCARCINOMA
F107P17Y	93	3.91	0.0477	1.76	SEP-24-76	2997	0.73	PERFORATION (INTESTINE)
M108P17Y	92	4.32	0.0473	1.75	OCT-08-76	5619	1.30	HEPATOCELLULAR DEGENERATION, LIVER
F109P17Y	88	3.06	0.0510	1.89	APR-20-78	4457	1.13	ADENOCARCINOMA, COLON
M110P17Y	92	3.07	0.0464	1.72	JUL-11-78	5017	1.15	HEPATOCELLULAR CARCINOMA, LIVER
F111P17Y	92	3.02	0.0471	1.74	JUL-11-78	5118	1.19	MAST CELL SARCOMA, ABDOMEN
F501P17+	1725	10.0	0.0456	1.69	JUN-24-75	2163	0.82	MAMMARY ADENOCARCINOMA

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F502P17+	1732	10.0	0.0416	1.54	DEC-16-75	3771	1.11	OSTEOSARCOMA,THROMBOEMBOLISM
F503P17+	1826	10.2	0.0519	1.92	MAY-13-76	3502	1.32	THROMBOEMBOLISM,(KIDNEY) AMYLOIDOSIS
F504P17+	1831	11.2	0.0527	1.95	JUL-06-77	3337	1.29	MAMMARY ADENOCARCINOMA
F505P17+	1846	9.96	0.0441	1.63	MAY-09-78	2577	0.90	OSTEOSARCOMA
F506P17+	1823	9.56	0.0449	1.66	MAY-09-78	3803	1.20	BRONCHOPNEUMONIA
M507P17+	1849	10.7	0.0458	1.69	JUL-20-78	3011	1.05	OSTEOSARCOMA
M508P17+	1840	12.6	0.0430	1.59	SEP-07-78	3452	1.08	OSTEOSARCOMA (FEMUR)
M509P17+	1845	12.7	0.0498	1.84	NOV-30-78	2160	0.91	HEPATITIS
M510P17+	1835	11.5	0.0503	1.86	NOV-30-78	2002	0.85	OSTEOSARCOMA
M001P20	442	7.61	0.0853	3.16	DEC-01-52	2985	1.98	OSTEOSARCOMA
F002P20	422	7.73	0.112	4.14	MAR-02-53	2780	2.47	OSTEOSARCOMA
M003P20	485	10.5	0.0940	3.48	JUN-01-53	3185	2.29	OSTEOSARCOMA
M004P20	608	9.84	0.0862	3.19	SEP-16-53	2948	1.98	OSTEOSARCOMA
F005P20	594	8.12	0.0846	3.13	OCT-14-53	2423	1.68	OSTEOSARCOMA
F006P20	417	7.54	0.0902	3.34	MAY-12-54	2947	2.07	OSTEOSARCOMA
F007P20	485	8.40	0.0996	3.69	OCT-25-54	2093	1.78	EPIDERMOID CARCINOMA (FRONTAL SINUS)
M008P20	406	9.73	0.0957	3.54	MAR-15-55	1761	1.50	PNEUMONIA
F009P20	552	9.72	0.101	3.74	SEP-09-55	2014	1.75	OSTEOSARCOMA
F010P20	551	7.94	0.0968	3.58	NOV-22-55	2912	2.21	OSTEOSARCOMA
M011P20	599	10.3	0.0961	3.56	APR-24-56	1617	1.42	OSTEOSARCOMA
M012P20	622	9.98	0.100	3.70	MAY-29-56	2284	1.90	OSTEOSARCOMA
F101P20Y	91	2.60	0.0981	3.63	SEP-19-74	4900	2.37	OSTEOSARCOMA (FEMUR)
M102P20Y	91	2.85	0.106	3.92	SEP-19-74	4078	2.16	AMYLOIDOSIS (KIDNEY)
M103P20Y	93	4.27	0.0904	3.34	MAR-02-76	4370	1.96	CHOLANGIOCARCINOMA (LIVER),AMYLOIDOSIS (KIDNEY)
F104P20Y	92	3.12	0.0904	3.34	APR-13-76	5097	2.27	CHOLANGIOCARCINOMA, LIVER
M105P20Y	90	4.10	0.0963	3.56	APR-27-76	4146	1.99	OSTEOSARCOMA
F106P20Y	91	2.81	0.0961	3.56	APR-27-76	3117	1.53	OSTEOSARCOMA
F107P20Y	94	3.22	0.0980	3.63	SEP-22-76	4100	2.01	AMYLOIDOSIS (KIDNEY)
M108P20Y	91	3.69	0.0834	3.09	DEC-16-76	4957	2.04	CHONDROBLASTIC OSTEOSARCOMA, HUMERUS
F109P20Y	88	2.60	0.0921	3.41	MAY-09-78	2654	1.27	MYXOSARCOMA (LIVER)
M110P20Y	92	3.28	0.0929	3.44	JUL-11-78	2890	1.38	PARALYSIS (UNDETERMINED)
F111P20Y	92	3.18	0.0958	3.54	JUL-11-78	4430	2.11	GIANT CELL TUMOR, TIBIA
F501P20+	1787	10.2	0.0903	3.34	JUN-10-75	2288	1.69	OSTEOSARCOMA
F502P20+	1757	10.2	0.0908	3.36	MAR-05-76	1715	1.36	THROMBOEMBOLISM
F503P20+	1743	8.44	0.110	4.07	MAR-05-76	1879	1.77	OSTEOSARCOMA,THROMBOEMBOLISM
F504P20+	1874	8.87	0.0922	3.41	JUL-20-78	3305	2.25	UNDETERMINED
F505P20+	1855	7.60	0.0942	3.49	JUL-20-78	1623	1.35	PHEOCHROMOCYTOMA
F506P20+	1887	7.95	0.0923	3.42	SEP-07-78	2002	1.56	UNDETERMINED (NO TUMOR)
M507P20+	1855	11.8	0.0911	3.37	JUL-20-78	2258	1.69	LYMPHOSARCOMA

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F502P20 AND F503P20 WERE GIVEN TRACER 8.88 KBQ (0.24 UCI) PU-237 IN THE SAME INJECTION SOLUTION CONTAINING THEIR PU-239.

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M508P20+	1817	7.91	0.0917	3.39	SEP-07-78	2399	1.78	FIBROSARCOMA (SKELETON),CHOLANGIOCARCINOMA
M509P20+	1835	10.6	0.0979	3.62	NOV-30-78	2559	1.99	OSTEOSARCOMA
M510P20+	1794	12.0	0.0988	3.66	NOV-30-78	1728	1.49	NEPHRITIS,THROMBOEMBOLISM
M001P30	418	8.00	0.261	9.66	DEC-01-52	1476	4.25	OSTEOSARCOMA
F002P30	422	6.85	0.312	11.5	MAR-02-53	1947	6.50	OSTEOSARCOMA
M003P30	485	8.74	0.291	10.8	JUN-01-53	1604	5.10	OSTEOSARCOMA
M004P30	608	8.51	0.292	10.8	SEP-16-53	1950	6.09	OSTEOSARCOMA
F005P30	650	8.22	0.288	10.7	OCT-14-53	1504	4.77	OSTEOSARCOMA
F006P30	415	8.38	0.282	10.4	MAY-12-54	1617	4.98	OSTEOSARCOMA
F007P30	485	9.00	0.314	11.6	OCT-25-54	1627	5.58	OSTEOSARCOMA
M008P30	406	9.73	0.300	11.1	MAR-15-55	1771	5.75	OSTEOSARCOMA
F009P30	552	7.67	0.300	11.1	SEP-09-55	1894	6.10	OSTEOSARCOMA
F010P30	533	8.94	0.298	11.0	NOV-22-55	1546	5.06	OSTEOSARCOMA
M011P30	599	10.5	0.309	11.4	APR-24-56	1198	4.17	OSTEOSARCOMA
M012P30	622	10.2	0.308	11.4	MAY-29-56	1659	5.57	OSTEOSARCOMA
M081P30Y	91	4.03	0.320	11.8	APR-25-72	2590	4.31	MYXOSARCOMA (SKELETON)
M086P30Y	89	3.29	0.319	11.8	APR-25-72	3368	5.44	CHOLANGIOSARCOMA PROSTATITIS
M089P30Y	89	4.23	0.312	11.5	APR-25-72	2942	4.71	OSTEOSARCOMA
F101P30Y	91	2.88	0.332	12.3	SEP-19-74	2290	4.01	FIBROSARCOMA (LIVER)
M102P30Y	93	3.93	0.316	11.7	APR-27-76	2935	4.76	OSTEOSARCOMA
F103P30Y	92	3.54	0.269	9.95	APR-13-76	2410	3.40	OSTEOSARCOMA
M104P30Y	92	4.65	0.317	11.7	APR-27-76	2564	4.23	OSTEOSARCOMA
M105P30Y	91	3.86	0.312	11.5	APR-27-76	2101	3.49	OSTEOSARCOMA
F106P30Y	91	4.22	0.315	11.7	JUN-01-76	2692	4.39	OSTEOSARCOMA
F107P30Y	93	3.69	0.295	10.9	SEP-24-76	2666	4.07	OSTEOSARCOMA
M108P30Y	90	3.56	0.283	10.5	DEC-16-76	1873	2.87	BILIARY OBSTRUCTION
F109P30Y	88	2.78	0.300	11.1	MAY-09-78	2906	4.48	OSTEOSARCOMA
F501P30+	1718	10.3	0.290	10.7	JUN-17-75	1634	4.19	OSTEOSARCOMA
F502P30+	1739	9.56	0.298	11.0	DEC-23-75	1456	3.92	OSTEOSARCOMA
F503P30+	1887	10.9	0.273	10.1	SEP-07-78	1538	3.75	OSTEOSARCOMA
F504P30+	1843	9.09	0.318	11.8	NOV-30-78	1078	3.25	NEPHRITIS
F505P30+	1835	8.19	0.312	11.5	NOV-30-78	1419	4.02	OSTEOSARCOMA
F506P30+	1823	7.55	0.274	10.1	SEP-07-78	364	1.05	SURGICAL COMPLICATIONS
M507P30+	1853	11.8	0.274	10.1	SEP-07-78	1421	3.53	OSTEOSARCOMA
M508P30+	1829	10.2	0.304	11.2	NOV-02-78	1545	4.20	OSTEOSARCOMA
M509P30+	1817	11.6	0.306	11.3	NOV-02-78	1066	3.10	OSTEOSARCOMA
M510P30+	1794	11.1	0.313	11.6	NOV-30-78	1706	4.68	OSTEOSARCOMA
M001P40	442	7.61	0.823	30.5	DEC-01-52	1724	16.3	OSTEOSARCOMA
F002P40	568	8.65	1.03	38.1	MAR-02-53	1556	18.6	OSTEOSARCOMA
M003P40	485	9.36	0.929	34.4	JUN-01-53	1198	13.1	OSTEOSARCOMA
M004P40	566	8.74	0.974	36.0	SEP-16-53	1066	12.4	OSTEOSARCOMA
F005P40	650	7.05	0.872	32.3	OCT-14-53	1245	12.8	OSTEOSARCOMA
F006P40	420	9.26	0.811	30.0	MAY-12-54	1357	12.9	OSTEOSARCOMA

B.5 ^{239}Pu, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F007P40	485	8.45	0.963	35.6	OCT-25-54	1198	13.6	OSTEOSARCOMA
M008P40	651	9.22	0.887	32.8	MAR-15-55	1157	12.1	OSTEOSARCOMA
F009P40	552	8.58	0.960	35.5	SEP-09-55	1343	15.1	OSTEOSARCOMA
F010P40	527	6.48	0.868	32.1	NOV-22-55	1241	12.7	OSTEOSARCOMA
M011P40	596	9.56	0.927	34.3	APR-24-56	1288	14.0	OSTEOSARCOMA
M012P40	598	11.4	0.838	31.0	MAY-29-56	1463	14.3	OSTEOSARCOMA
M001P50	418	8.86	2.67	98.8	DEC-01-52	1324	43.3	OSTEOSARCOMA
F002P50	1150	8.75	3.30	122.	MAR-02-53	1576	54.7	OSTEOSARCOMA,CRIPPLING FRACTURE
M003P50	515	8.10	3.00	111.	JUN-01-53	499	19.0	DEGENERATION (LIVER),ASCITES
M004P50	566	9.18	3.17	117.	SEP-16-53	1562	60.2	OSTEOSARCOMA
F005P50	691	8.77	2.77	102.	OCT-14-53	2059	68.5	OSTEOSARCOMA,DEGENERATION,HEMORRHAGE (LIVER)
F006P50	407	7.90	2.57	95.1	MAY-12-54	1194	37.7	OSTEOSARCOMA
F007P50	482	8.33	2.99	111.	OCT-25-54	1491	54.3	OSTEOSARCOMA,CRIPPLING FRACTURE
M008P50	497	9.55	2.69	99.5	MAR-15-55	1192	39.4	GINGIVITIS
F009P50	552	9.45	2.73	101.	SEP-09-55	1145	38.5	OSTEOSARCOMA,EPISTAXIS,CIRCULATORY FAILURE
M081P50Y	94	4.60	2.68	99.2	MAR-01-72	1161	22.1	OSTEOSARCOMA
F082P50Y	94	4.80	2.66	98.4	MAR-01-72	1295	23.9	OSTEOSARCOMA
F083P50Y	94	4.00	2.66	98.4	MAR-01-72	1442	26.2	OSTEOSARCOMA,FIBROSARCOMA (SOFT TISSUE)
F084P50Y	94	3.55	2.68	99.2	MAR-01-72	1259	23.6	OSTEOSARCOMA
F085P50Y	94	4.15	2.64	97.7	MAR-01-72	1134	21.3	OSTEOSARCOMA
M086P50Y	93	3.75	2.95	109.	APR-25-72	1345	27.4	OSTEOSARCOMA
F087P50Y	93	4.15	2.93	108.	APR-25-72	1119	23.4	OSTEOSARCOMA
F088P50Y	93	3.65	2.96	110.	APR-25-72	1227	25.5	OSTEOSARCOMA
M089P50Y	93	3.79	2.92	108.	APR-25-72	1443	28.7	OSTEOSARCOMA
M090P50Y	93	4.38	2.97	110.	APR-25-72	1137	24.0	OSTEOSARCOMA
M091P50Y	91	3.78	2.90	107.	APR-25-72	1491	29.3	OSTEOSARCOMA
M092P50Y	91	3.82	2.87	106.	APR-25-72	1616	31.03	OSTEOSARCOMA

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M042P00B WAS REMOVED FROM INJECTION TABLES BECAUSE DOG NEVER REACHED YOUNG ADULT AGE.

B.6 ^{224}Ra (Quickradium), Chronic Toxicity Study

DOG NUMBER	AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M001Q00M	458	11.6			MAY-19-77	2602		STATUS EPILEPTICUS
F002Q00M	647	10.7			MAY-19-77	3316		MAMMARY ADENOCARCINOMA
M003Q00M	646	10.4			NOV-30-77	2481		UNDETERMINED
F004Q00M	586	10.3			MAY-19-77	1244		PNEUMONIA
M005Q00M	646	11.3			NOV-30-77	4971		SYSTEMIC AMYLOIDOSIS
F006Q00M	586	9.58			MAY-19-77	4299		SYNOVIAL CELL SARCOMA
M041Q00	589	10.1			JAN-09-79	3544		MAST CELL SARCOMA, DISSEMINATED
F042Q00	597	9.48			MAY-02-79	5265		LIVING
M043Q00	638	9.95			SEP-12-78	4525		PANCREATITIS
F044Q00	597	7.82			MAY-02-79	3905		TRANSITIONAL CELL CARCINOMA, BLADDER
M045Q00	673	10.6			SEP-12-78	4872		CHRONIC NEPHRITIS, KIDNEY
F046Q00	619	11.2			AUG-10-77	3819		CARCINOMA (MAMMARY)
M081Q00M	639	10.4			FEB-14-79	2498		MELANOMA (MOUTH)
F082Q00M	623	7.80			FEB-14-79	5342		LIVING
M083Q00M	639	9.17			FEB-14-79	4709		MALIGNANT MELANOMA, MOUTH
F084Q00M	660	10.2			APR-25-79	3582		SOLID CARCINOMA, MAMMARY GLAND
M085Q00M	660	10.5			APR-25-79	4306		CARCINOMA,NASAL CAVITY
F086Q00M	626	8.85			APR-25-79	4780		ADENOCARCINOMA, LUNG
M001Q20M	647	11.9	0.291	10.8	MAY-19-77	4668	0.09	INTERVERTEBRAL DISC DISEASE
F002Q20M	647	10.9	0.317	11.7	MAY-19-77	2944	0.10	ENDOMETRITIS
M003Q20M	635	9.62	0.359	13.3	MAY-19-77	2156	0.11	THROMBOEMBOLISM, PANCREATITIS
F004Q20M	635	8.18	0.423	15.7	MAY-19-77	5021	0.13	HYPERADRENOCORTICISM
M005Q20M	643	10.1	0.342	12.7	MAY-19-77	1309	0.10	CHRONIC PANCREATITIS
F006Q20M	632	9.82	0.352	13.0	MAY-19-77	1797	0.11	MAMMARY ADENOCARCINOMA
M007Q20M	683	10.9	0.317	11.7	MAY-19-77	4670	0.10	INTERVERTEBRAL DISC DISEASE
F008Q20M	647	11.1	0.312	11.5	MAY-19-77	3835	0.09	TRANSITIONAL CELL CARCINOMA, URINARY BLADDER
M009Q20M	610	11.4	0.303	11.2	MAY-19-77	4280	0.09	HEMATOMA, SPLEEN
F010Q20M	610	8.52	0.406	15.0	MAY-19-77	3143	0.12	HERNIATION (CERVICAL DISC)
M011Q20M	610	10.3	0.336	12.4	MAY-19-77	4666	0.10	NEUROFIBROSARCOMA, CECUM
F012Q20M	610	8.62	0.401	14.8	MAY-19-77	3648	0.12	THROMBOEMBOLISM, KIDNEY FAILURE
M041Q20	704	11.2	0.365	13.5	JAN-09-79	2268	0.11	HYDROCEPHALUS
F042Q20	662	9.78	0.352	13.0	DEC-05-78	4353	0.11	CARCINOMA,MAMMARY GLAND
M043Q20	687	9.22	0.355	13.1	JAN-09-79	4307	0.11	GLOMERULONEPHRITIS
F044Q20	687	7.99	0.359	13.3	JAN-09-79	4783	0.11	MALIGNANT MELANOMA, MOUTH
M045Q20	621	9.15	0.344	12.7	DEC-05-78	4718	0.10	FIBRINOUS PNEUMONIA, LUNG
F046Q20	687	10.8	0.362	13.4	JAN-09-79	4875	0.11	OSTEOSARCOMA, MANDIBLE
M047Q20	636	11.1	0.343	12.7	NOV-30-77	2792	0.10	ADENOCARCINOMA (RECTUM)
F048Q20	603	8.05	0.356	13.2	JAN-09-79	5327	0.11	FIBROSARCOMA,SPLEEN
M049Q20	646	12.2	0.348	12.9	NOV-30-77	3904	0.10	CHOLANGIOCARCINOMA (LIVER)
F050Q20	667	11.4	0.383	14.2	SEP-12-78	4026	0.11	PYOMETRA/SEPTICEMIA
M051Q20	636	10.7	0.348	12.9	NOV-30-77	2090	0.10	THROMBOEMBOLISM
F052Q20	619	11.2	0.344	12.7	AUG-10-77	3129	0.10	ADENOCARCINOMA (NASAL CAVITY)
M081Q20M	662	10.6	0.283	10.5	FEB-14-79	3381	0.08	CNS DISEASE, CAUSE UNDETERMINED

B.6 ^{224}Ra (Quickradium), Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F082Q20H	639	8.68	0.345	12.8	FEB-14-79	3452	0.10	MELANOMA (SOFT PALATE)
M083Q20H	594	8.10	0.370	13.7	FEB-14-79	2925	0.11	LYMPHOSARCOMA
F084Q20H	594	7.32	0.409	15.1	FEB-14-79	3187	0.12	GLOMERULONEPHRITIS (KIDNEY)
M085Q20H	590	9.23	0.325	12.0	FEB-14-79	3498	0.10	LYMPHOSARCOMA, DISSEMINATED
F086Q20H	583	8.28	0.362	13.4	FEB-14-79	4588	0.11	GLOMERULONEPHRITIS
M087Q20H	694	10.6	0.336	12.4	APR-25-79	3715	0.10	LYMPHOSARCOMA, SMALL INTESTINE
F088Q20H	626	9.59	0.372	13.8	APR-25-79	4488	0.10	MYELOPROLIFERATIVE DISEASE
M089Q20H	653	9.93	0.359	13.3	APR-25-79	5266	0.11	ATROPHY,PANCREAS
F090Q20H	626	10.0	0.356	13.2	APR-25-79	4894	0.11	LYMPHOSARCOMA
M091Q20H	695	10.3	0.346	12.8	APR-25-79	3743	0.10	HEPATITIS
F092Q20H	596	7.91	0.450	16.7	APR-25-79	3711	0.14	TUBULAR ADENOCARCINOMA, MAMMARY GLAND
M001Q30H	647	10.3	1.06	39.2	MAY-19-77	3938	0.32	INTERVERTEBRAL DISC PROLAPSE, HEPATITIS (LIVER)
F002Q30H	647	10.4	1.05	38.8	MAY-19-77	3754	0.32	THROMBOEMBOLISM (PULMONARY)
M003Q30H	642	10.3	1.06	39.2	MAY-19-77	4576	0.32	LYMPHOSARCOMA
F004Q30H	643	8.16	1.33	49.2	MAY-19-77	2685	0.40	PANCREATIC ATROPHY, ENTERITIS
M005Q30H	632	11.8	0.922	34.1	MAY-19-77	4180	0.28	GASTROENTERITIS
F006Q30H	647	10.4	1.05	38.8	MAY-19-77	3632	0.32	OSTEOSARCOMA
M007Q30H	642	11.8	0.922	34.1	MAY-19-77	2862	0.28	INTUSSUSCEPTION (ILEUM)
F008Q30H	632	9.10	1.20	44.4	MAY-19-77	3716	0.36	THROMBOEMBOLISM, CHROMATOPHORE ADENOMA
M009Q30H	666	13.4	0.822	30.4	MAY-19-77	3095	0.25	PNEUMONIA, CHRONIC ENTERITIS
F010Q30H	666	11.3	0.962	35.6	MAY-19-77	4338	0.29	TRANSITIONAL CARCINOMA, NASAL CAVITY
M011Q30H	610	10.5	1.04	38.5	MAY-19-77	4324	0.31	FIBROBLASTIC OSTEOSARCOMA, MAXILLA
F012Q30H	610	9.75	1.12	41.4	MAY-19-77	3855	0.34	LYMPHOSARCOMA, DISSEMINATED
M041Q30	671	9.98	1.10	40.7	DEC-05-78	4301	0.33	PYELONEPHRITIS
F042Q30	705	9.04	1.11	41.1	JAN-09-79	3508	0.33	MYELOFIBROSIS (BONE MARROW)
M043Q30	656	9.42	1.12	41.4	DEC-05-78	2154	0.34	PANCREATITIS, PNEUMONIA
F044Q30	688	8.42	1.11	41.1	JAN-09-79	4669	0.33	CARCINOMA, MAMMARY
M045Q30	704	11.3	1.15	42.6	JAN-09-79	4331	0.35	GLOMERULONEPHRITIS
F046Q30	687	9.68	1.15	42.6	JAN-09-79	2242	0.34	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M047Q30	656	10.2	1.14	42.2	JAN-09-79	4978	0.34	SPONDYLOSIS, VERTEBRAE; DISC PROTRUSION
F048Q30	687	8.95	1.12	41.4	JAN-09-79	4626	0.34	CARCINOMA,MAMMARY GLAND
M049Q30	630	9.58	1.12	41.4	NOV-30-77	4767	0.34	CARCINOMA,PANCREAS
F050Q30	572	9.40	1.21	44.8	SEP-12-78	4461	0.36	SYSTEMIC AMYLOIDOSIS
M051Q30	638	9.85	1.08	40.0	NOV-30-77	3731	0.32	HEMANGIOSARCOMA (HEART)
F052Q30	634	9.97	1.10	40.7	AUG-10-77	3182	0.33	ENDOMETRITIS
M081Q30H	657	12.1	0.720	26.6	FEB-14-79	5342		LIVING
F082Q30H	639	8.73	0.999	37.0	FEB-14-79	4883	0.30	CARCINOMA, MAMMARY GLAND
M083Q30H	664	8.28	1.05	38.8	FEB-14-79	2602	0.32	FIBROSARCOMA (SKELETON)
F084Q30H	594	6.77	1.29	47.7	FEB-14-79	5124	0.39	NEPHRITIS,KIDNEY
M085Q30H	590	7.75	1.12	41.4	FEB-14-79	3852	0.34	PERITONITIS
F086Q30H	583	8.07	1.08	40.0	FEB-14-79	4296	0.32	GRANULOSA CELL TUMOR,OVARY
M087Q30H	664	9.11	1.11	41.1	APR-25-79	3009	0.33	SPONDYLOSIS DEFORMANS
F088Q30H	626	9.91	1.02	37.7	APR-25-79	3032	0.31	MYXOSARCOMA (ORAL)
M089Q30H	694	9.84	1.02	37.7	APR-25-79	4137	0.31	PAPILLARY ADENOCARCINOMA, LUNG

B.6 ^{224}Ra (Quickradium), Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F090Q30H	626	8.55	1.18	43.7	APR-25-79	4095	0.35	HEMANGIOSARCOMA, SUBCUTIS
M091Q30H	653	7.54	1.34	49.6	APR-25-79	3807	0.40	RENAL AMYLOIDOSIS
F092Q30H	607	8.95	1.13	41.8	APR-25-79	5272		LIVING
M001Q40H	653	10.2	3.23	120.	MAY-19-77	3563	0.97	EPIDERMOID CARCINOMA (ORAL)
F002Q40H	653	9.44	3.49	129.	MAY-19-77	1580	1.05	THORACIC EXTRAVASATION OF LYMPH, OVARIAN PAPILLARY CARCINOMA
M003Q40H	642	13.5	2.44	90.3	MAY-19-77	3637	0.73	HEMANGIOSARCOMA (ABDOMEN)
F004Q40H	643	9.10	3.62	134.	MAY-19-77	3787	1.09	OSTEOSARCOMA, METATARSUS
M005Q40H	643	10.5	3.14	116.	MAY-19-77	3235	0.94	ADENOCARCINOMA (NASAL CAVITY)
F006Q40H	647	10.8	3.05	113.	MAY-19-77	1923	0.92	MAMMARY ADENOCARCINOMA
M041Q40	607	10.9	3.04	112.	NOV-30-77	5238	0.91	ADENOCARCINOMA, LUNG; CARCINOMA, KIDNEY
F042Q40	706	10.8	3.28	121.	JAN-09-79	4012	0.98	AUTOIMMUNE HEMOLYTIC ANEMIA
M043Q40	662	11.2	3.25	120.	DEC-05-78	4018	0.98	SQUAMOUS CELL CARCINOMA, MAXILLA
F044Q40	691	7.74	3.28	121.	JAN-09-79	4285	0.98	ODONTOAMELOBLASTOMA
M045Q40	630	10.2	3.28	121.	NOV-30-77	4615	0.98	OSTEOBLASTIC OSTEOSARCOMA, THORACIC VERTEBRA
F046Q40	674	8.85	3.56	132.	SEP-12-78	4979	1.07	CARCINOMA, KIDNEY
M081Q40H	657	11.0	2.90	107.	FEB-14-79	3224	0.87	HEMANGIOSARCOMA, ADRENAL GLAND
F082Q40H	639	8.80	3.62	134.	FEB-14-79	5201	1.09	LYMPHOMA,THYMUS
M083Q40H	608	10.6	3.01	111.	FEB-14-79	5342		LIVING
F084Q40H	678	10.4	3.01	111.	APR-25-79	3873	0.90	LEIOMYOFIBROSARCOMA, VAGINA
M085Q40H	664	8.25	3.80	141.	APR-25-79	2729	1.14	SPONDYLOSIS DEFORMANS
F086Q40H	688	9.37	3.35	124.	APR-25-79	4647	1.00	CONGESTIVE FAILURE, HEART
M001Q50H	653	10.6	8.64	320.	MAY-19-77	2433	2.59	OSTEOSARCOMA
F002Q50H	653	11.4	8.04	297.	MAY-19-77	1994	2.41	OSTEOSARCOMA
M003Q50H	643	10.6	8.64	320.	MAY-19-77	2016	2.59	UNDETERMINED (NO SKELETAL TUMOR)
F004Q50H	647	8.35	11.0	406.	MAY-19-77	1636	3.29	OSTEOSARCOMA
M005Q50H	635	9.88	9.27	343.	MAY-19-77	2021	2.78	OSTEOSARCOMA
F006Q50H	647	9.12	10.0	370.	MAY-19-77	2259	3.00	OSTEOSARCOMA
M041Q50	705	11.4	9.65	357.	JAN-09-79	3742	2.90	FIBROSARCOMA, LIVER
F042Q50	671	7.76	10.2	377.	DEC-05-78	3066	3.06	OSTEOSARCOMA
M043Q50	697	9.41	9.59	355.	JAN-09-79	9	2.43	BLOOD DYSCRASIA
M043Q50A	722	11.2	10.3	381.	JUL-03-79	12	2.83	PURPURA HEMORRHAGICA
F044Q50	656	8.08	10.3	381.	DEC-05-78	16	3.02	PURPURA HEMORRHAGICA
F044Q50A	672	10.0	10.8	400.	JUL-10-79	2841	3.24	MAMMARY ADENOCARCINOMA
M045Q50	604	9.75	12.0	444.	DEC-07-77	3800	3.60	MYXOMA (OMENTUM & LIVER), OSTEOSARCOMA, VERTEBRA
F046Q50	656	8.22	9.64	357.	JAN-09-79	3591	2.89	TUBULAR ADENOCARCINOMA, MAMMARY GLAND
M081Q50H	618	8.37	10.0	370.	FEB-14-79	2878	3.00	OSTEOSARCOMA, THROMBOEMBOLISM AMYLOIDOSIS
F082Q50H	664	9.73	8.63	319.	FEB-14-79	2941	2.59	OSTEOSARCOMA
M083Q50H	618	9.00	9.33	345.	FEB-14-79	3422	2.80	CNS DISEASE, CAUSE UNDETERMINED
F084Q50H	678	11.2	9.93	367.	APR-25-79	2673	2.98	SPLENIC HEMORRHAGE, MAMMARY ADENOCARCINOMA
M085Q50H	678	11.7	9.50	352.	APR-25-79	2487	2.85	OSTEOSARCOMA
F086Q50H	660	11.6	9.59	355.	APR-25-79	972	2.88	FIBROSARCOMA

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GROUPS 41-52 RECEIVED RA-224 IN 1 INJECTION. 81-92 RECEIVED RA-224 IN 10 FRACTIONS (1/WEEK). 1-12 RECEIVED RA-224 IN 50 FRACTIONS (1/WEEK).

B.7 ^{226}Ra, Chronic Toxicity Study

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M001R00	558	8.03			APR-20-53	3116		SEMINOMA, LYMPHOSARCOMA
M002R00	487	14.6			NOV-16-53	3675		TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
F003R00	601	11.4			MAR-10-54	2139		STATUS EPILEPTICUS
M004R00	461	11.0			APR-07-54	5284		NEPHRITIS, THROMBOEMBOLISM
M005R00	460	6.57			JUN-22-54	4018		THROMBOEMBOLISM
F006R00	483	8.43			JUL-27-54	3182		STATUS EPILEPTICUS
M007R00	511	11.0			AUG-24-54	3360		STATUS EPILEPTICUS, NEPHRITIS
F008R00	638	8.21			DEC-21-54	3361		PANCREAS ADENOCARCINOMA
F009R00	700	11.7			APR-11-55	1550		AORTIC BODY TUMOR
M010R00	522	10.9			JUL-27-55	4698		NEPHRITIS
F011R00	544	10.2			DEC-20-55	4575		FIBROMA (VAGINA)
F012R00	501	8.68			JAN-17-56	4283		PNEUMONIA
M013R00	515	12.3			MAR-04-64	4752		MELANOMA (MOUTH)
F014R00	536	10.8			OCT-23-64	5725		THROMBOEMBOLISM, ISLET CELL TUMOR
M015R00	564	12.8			FEB-04-65	4372		PANCREATITIS, HYDROCEPHALUS
F016R00	469	10.0			APR-07-65	3677		EPIDERMOID CARCINOMA (LUNG)
M017R00	469	12.5			APR-27-66	5042		SALIVARY GLAND ADENOCARCINOMA
F018R00	497	12.0			MAY-25-66	5321		HEMANGIOSARCOMA (SOFT TISSUE)
F019R00	533	8.42			OCT-13-66	4726		PNEUMONIA, MAMMARY ADENOCARCINOMA
M020R00	536	9.70			DEC-29-66	4890		SENILITY, INANITION
F021R00	549	9.90			JAN-26-67	4234		MAMMARY ADENOCARCINOMA
M022R00	533	12.1			MAR-22-67	3907		SEPTICEMIA
F031R00B	536	10.6			OCT-23-64	4458		STATUS EPILEPTICUS
F031R00C	536	9.88			OCT-23-64	4690		BILIARY OBSTRUCTION, LEIOMYOSARCOMA (VAGINA)
F031R00D	542	9.90			SEP-21-65	4889		PANCREATITIS
F032R00B	542	7.80			SEP-21-65	4657		VALVULAR INSUFFICIENCY, PANCREATITIS
F032R00C	532	11.7			SEP-21-65	4784		MAMMARY CARCINOMA
F032R00D	532	9.70			SEP-21-65	4828		TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
F033R00B	532	9.80			SEP-21-65	3670		MAMMARY ADENOCARCINOMA
F033R00C	496	9.50			MAY-25-66	4509		MELANOMA (MOUTH)
F033R00D	496	11.8			MAY-25-66	3916		MAMMARY ADENOCARCINOMA
F034R00B	525	8.20			JAN-26-67	4929		PANCREATITIS
F034R00C	520	8.90			MAR-22-67	4605		PANCREATITIS
F034R00D	484	9.90			MAR-22-67	3185		HEMANGIOSARCOMA (SOFT TISSUE)
F035R00B	502	9.41			FEB-01-68	5349		OVARIAN ADENOCARCINOMA
F035R00C	502	9.38			FEB-01-68	5066		SENILITY
F035R00D	552	8.86			JAN-09-69	5124		ENDOMETRITIS, SEPTICEMIA
F036R00B	467	10.1			JUL-02-68	5281		MAMMARY ADENOCARCINOMA
F036R00C	467	9.17			JUL-02-68	4538		MAMMARY ADENOCARCINOMA
F036R00D	467	9.08			JUL-02-68	4403		MELANOMA (MOUTH)
F037R00B	801	11.1			MAY-20-69	4093		LYMPHOSARCOMA
F037R00C	501	10.4			SEP-23-70	2788		PNEUMONIA, STATUS EPILEPTICUS
F037R00D	501	10.9			SEP-23-70	5621		MAMMARY ADENOCARCINOMA

B.7 ^{226}Ra, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F038R00B	501	11.5			SEP-23-70	3821		ENCEPHALITIS
M101R00Y								REASSIGNED, SEE M515R40+
M102R00Y								REASSIGNED, SEE M516R40+
M103R00Y								REASSIGNED, SEE M517R40+
F104R00Y								REASSIGNED, SEE F518R40+
F105R00Y								REASSIGNED, SEE F519R40+
F106R00Y								REASSIGNED, SEE F520R40+
M107R00Y	94	4.32			MAR-09-77	5256		LYMPHOSARCOMA
F108R00Y	93	4.22			MAR-16-77	4301		SOLID CARCINOMA, MAMMARY GLAND
F109R00Y	88	2.92			JAN-19-78	5733		LIVING
M013R02	529	9.77	0.00577	0.213	MAR-04-64	4518	0.20	MELANOMA (MOUTH)
F014R02	460	8.10	0.00836	0.309	OCT-23-64	3448	0.42	MELANOMA (MOUTH)
M015R02	504	10.8	0.00873	0.323	FEB-04-65	4102	0.31	CIRCULATORY FAILURE
F016R02	486	8.90	0.00665	0.246	APR-07-65	4190	0.27	LYMPHOSARCOMA, MELANOMA (SKIN)
M017R02	494	11.8	0.00711	0.263	APR-27-66	5056	0.34	SENILITY, NEPHRITIS, LYMPHADENOPATHY
F018R02	497	9.30	0.00652	0.241	MAY-25-66	3387	0.24	LUNG CARCINOMA, ADENOCARCINOMA
F019R02	533	10.6	0.00785	0.290	OCT-13-66	3611	0.31	PNEUMONIA
M020R02	546	11.4	0.00676	0.250	DEC-29-66	3493	0.21	LYMPHOSARCOMA
F021R02	549	11.5	0.00687	0.254	JAN-26-67	3101	0.27	MAMMARY ADENOCARCINOMA
M022R02	533	12.9	0.00961	0.356	MAR-22-67	5000	0.40	PANCREATITIS
M013R05	529	11.0	0.0171	0.633	MAR-04-64	3676	0.58	CHOLANGIOCARCINOMA
F014R05	510	9.75	0.0220	0.814	OCT-23-64	5079	0.86	OSTEOSARCOMA
M015R05	490	10.4	0.0263	0.973	FEB-04-65	4297	0.83	MELANOMA (MOUTH)
F016R05	500	11.4	0.0205	0.759	APR-07-65	4141	0.81	MAMMARY ADENOCARCINOMA
M017R05	523	9.20	0.0215	0.796	APR-27-66	4052	0.73	MELANOMA (MOUTH)
F018R05	496	9.10	0.0197	0.729	MAY-25-66	4900	0.97	MELANOMA (MOUTH)
F019R05	533	10.0	0.0230	0.851	OCT-13-66	5059	1.06	MAMMARY CARCINOMA, DEGENERATION (KIDNEY)
M020R05	536	13.2	0.0206	0.762	DEC-29-66	4526	0.94	NEPHRITIS
F021R05	538	8.80	0.0208	0.770	JAN-26-67	4281	0.68	HEMORRHAGE (HYPOTHALAMUS), ULCER (STOMACH)
M022R05	520	12.3	0.0290	1.070	MAR-22-67	3192	1.01	THYROID ADENOCARCINOMA
M031R05B	508	11.4	0.0210	0.777	APR-27-66	4310	0.86	THYROID ADENOCARCINOMA,ANKYLOSING SPONDYLITIS
F031R50C	537	9.40	0.0235	0.870	DEC-22-65	4393	0.95	TRAUMA
F031R05D	537	11.7	0.0238	0.881	DEC-22-65	4797	0.92	THYROID ADENOCARCINOMA
M032R05B	496	13.4	0.0196	0.725	MAY-25-66	3219	0.75	THYMOMA
F032R05C	519	10.1	0.0239	0.884	DEC-22-65	4180	0.86	ADAMANTINOMA (MANDIBLE)
F032R05D	509	10.1	0.0240	0.888	DEC-22-65	3870	0.87	HEMANGIOSARCOMA (SOFT TISSUE)
M033R05B	497	12.9	0.0194	0.718	MAY-25-66	3848	0.85	EPIDERMOID CARCINOMA (MOUTH)
F033R05C	527	10.6	0.0212	0.784	APR-27-66	4935	0.96	INANITION UNDETERMINED (NO SKELETAL TUMOR)
F033R05D	527	8.70	0.0217	0.803	APR-27-66	4697	0.99	BILE DUCT OBSTRUCTION, KIDNEY FAILURE
M034R05B	496	10.5	0.0196	0.725	MAY-25-66	5249	0.96	ANKYLOSING SPONDYLITIS, MELANOMA (MOUTH)
F034R05C	524	9.90	0.0215	0.796	APR-27-66	4322	0.63	MAMMARY ADENOCARCINOMA
F034R05D	508	9.70	0.0212	0.784	APR-27-66	4628	0.92	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M035R05B	536	10.4	0.0205	0.759	DEC-29-66	4367	0.78	PROSTATITIS

B.7 ^{226}Ra, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F035R05C	532	9.00	0.0201	0.744	DEC-29-66	4990	0.74	SURGICAL COMPLICATIONS
F035R05D	532	10.2	0.0202	0.747	DEC-29-66	5171	0.81	THROMBOEMBOLISM, MAMMARY ADENOCARCINOMA
M101R05Y	88	4.32	0.0186	0.688	MAR-25-75	5217	0.95	MESOTHELIOMA/PAPILLARY ADENOCARCINOMA, LUNG
M102R05Y	93	4.44	0.0187	0.692	APR-24-75	4798	0.80	ADENOCARCINOMA (COLON)
M103R05Y	90	3.61	0.0192	0.710	MAY-06-75	5091	0.89	LYMPHOSARCOMA, SMALL INTESTINE
F104R05Y	88	4.09	0.0184	0.681	MAR-25-75	5249	1.02	PYELONEPHRITIS
F105R05Y	88	4.08	0.0184	0.681	MAR-25-75	4811	0.87	THROMBOSIS (LUNG), AMYLOIDOSIS KIDNEY
F106R05Y	93	3.60	0.0188	0.696	APR-24-75	4978	0.81	BETA CELL CARCINOMA, PANCREAS
M107R05Y	93	3.69	0.0191	0.707	MAR-08-77	4428	0.82	CARCINOMA, PROSTATE
M108R05Y	88	2.54	0.0185	0.685	JAN-19-78	5060	0.94	SARCOMA, PANCREAS
F109R05Y	90	3.45	0.0177	0.655	MAR-09-78	5604	0.93	CARCINOMA,MAMMARY GLAND
F110R05Y	91	3.11	0.0195	0.722	AUG-08-78	3001	0.49	PULMONARY CALCIFICATION, MAMMARY ADENOCARCINOMA
M001R10	471	8.48	0.0618	2.29	APR-20-53	5727	1.73	MELANOMA (MOUTH)
M002R10	627	10.0	0.0876	3.24	NOV-16-53	4054	1.96	SEMINOMA
F003R10	706	8.68	0.0576	2.13	MAR-10-54	3860	0.85	MAMMARY ADENOCARCINOMA
M004R10	414	8.60	0.0642	2.38	APR-07-54	2038	1.10	TRAUMA
M005R10	490	11.7	0.0436	1.61	JUN-22-54	3780	1.25	TRANS. CELL CARC. (URINARY BLADDER),HYDRONEPHROSIS
F006R10	483	7.23	0.0584	2.16	JUL-27-54	5260	1.93	NEPHRITIS
M007R10	511	11.4	0.0651	2.41	AUG-24-54	3544	1.71	STATUS EPILEPTICUS
F008R10	861	8.98	0.0559	2.07	DEC-21-54	2988	0.97	LYMPHOSARCOMA
F009R10	781	9.88	0.0521	1.93	APR-11-55	4399	1.04	PNEUMONIA
M010R10	523	11.5	0.0573	2.12	JUL-27-55	4003	1.65	FIBROSARCOMA GINGIVA, MELANOMA (EYE)
F011R10	511	11.2	0.0522	1.93	DEC-20-55	5636	1.61	MELANOMA (EYE), MAMMARY ADENOCARCINOMA
F012R10	501	9.71	0.0444	1.64	JAN-17-56	3978	1.29	MELANOMA (MOUTH)
M013R10	529	11.7	0.0527	1.95	MAR-04-64	3739	1.82	CYST (PROSTATE), ADENOCARCINOMA (PROSTATE)
F014R10	510	10.5	0.0701	2.59	OCT-23-64	1729	1.63	STATUS EPILEPTICUS
M015R10	490	8.88	0.0797	2.95	FEB-04-65	893	0.92	SUBDURAL HEMORRHAGE (SPINAL CORD)
F016R10	501	8.99	0.0611	2.26	APR-07-65	4557	1.93	LYMPHOSARCOMA
M017R10	494	11.4	0.0639	2.36	APR-27-66	5601	2.63	NEPHRITIS
F018R10	496	10.0	0.0589	2.18	MAY-25-66	3625	1.67	MAMMARY ADENOCARCINOMA
F019R10	533	11.6	0.0682	2.52	OCT-13-66	3612	2.33	OSTEOSARCOMA
M020R10	536	10.0	0.0610	2.26	DEC-29-66	4260	2.71	CHONDROSARCOMA (ETHMOID), ADENOCARCINOMA (ADRENAL)
F021R10	525	8.10	0.0633	2.34	JAN-26-67	5189	2.07	PNEUMONIA
M022R10	484	10.9	0.0861	3.19	MAR-22-67	4845	4.59	PROSTATE ADENOCARC.,TRANS. CELL CARC. (BLADDER)
F031R10B	509	10.4	0.0712	2.63	DEC-22-65	3009	1.77	STATUS EPILEPTICUS
M101R10Y	88	4.09	0.0545	2.02	MAR-25-75	5787	2.59	ADENOMA,PITUITARY
M102R10Y	92	4.54	0.0546	2.02	APR-01-75	4384	2.22	MAST CELL SARCOMA (INTESTINE)
M103R10Y	90	3.03	0.0564	2.09	MAY-06-75	4264	2.09	CHRONIC PANCREATITIS
F104R10Y	88	3.71	0.0541	2.00	MAR-25-75	5161	2.26	CHONDROSARCOMA, NASAL CAVITY
F105R10Y	92	4.70	0.0528	1.95	APR-01-75	4182	1.90	CHRONIC PANCREATITIS
F106R10Y	93	4.20	0.0557	2.06	APR-24-75	4144	2.17	HEMORRHAGE (SPLEEN)
M107R10Y	93	4.12	0.0575	2.13	MAR-08-77	2010	1.23	INFECTION
M108R10Y	88	2.52	0.0548	2.03	JAN-19-78	2467	1.27	THROMBOEMBOLISM

B.7 ^{226}Ra, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F109R10Y	90	3.61	0.0544	2.01	MAR-09-78	3907	1.84	HEPATOCELLULAR CARCINOMA
M111R10Y	90	2.95	0.0527	1.95	MAY-23-78	4283	2.25	ADENOCARCINOMA, NASAL MUCOSA
M001R17	523	9.98	0.137	5.07	JAN-17-56	4438	3.61	THROMBOEMBOLISM, MELANOMA EYE
M002R17	598	7.85	0.163	6.03	NOV-30-56	1273	1.27	LYMPHOSARCOMA
M002R17A	493	12.0	0.222	8.21	MAR-06-63	3254	7.22	FIBROSARCOMA (GUM OF MAXILLA)
F003R17	473	13.1	0.165	6.11	DEC-20-55	3268	4.42	MAMMARY ADENOCARCINOMA
M004R17	514	6.20	0.163	6.03	DEC-20-55	5495	5.39	NEPHRITIS
M005R17	511	10.1	0.151	5.59	DEC-20-55	4107	5.08	OSTEOSARCOMA
F006R17	491	7.90	0.152	5.62	DEC-20-55	3432	4.89	GENERALIZED CALCINOSIS
M007R17	598	7.17	0.163	6.03	NOV-30-56	3142	3.30	TOXEMIA (BACTERIAL), THYROID ADENOCARCINOMA
F008R17	491	9.50	0.154	5.70	DEC-20-55	2577	3.92	DRUG ALLERGY
F009R17	598	7.55	0.168	6.22	NOV-30-56	3914	2.87	ENDOMETRITIS
M010R17	590	9.57	0.167	6.18	NOV-30-56	557	1.14	TRAUMA
M010R17A	545	10.6	0.183	6.77	JAN-07-59	4903	5.57	UNDIFFERENTIATED MALIGNANCY,(NO SKELETAL TUMOR)
F011R17	598	8.17	0.165	6.11	NOV-30-56	5324	3.34	MELANOMA (MOUTH), THYROID ADENOCARCINOMA
F012R17	590	8.95	0.167	6.18	NOV-30-56	2399	2.28	ENCEPHALOPATHY
M101R17Y	92	4.19	0.163	6.03	APR-01-75	4587	6.83	MALABSORPTION SYNDROME
M102R17Y	93	5.45	0.167	6.18	APR-24-75	3844	5.28	SARCOMA (MYOCARDIUM)
M103R17Y	90	2.84	0.167	6.18	MAY-06-75	3450	5.80	INANITION
F104R17Y	88	3.65	0.159	5.88	MAR-25-75	2369	3.97	STATUS EPILEPTICUS
F105R17Y	88	3.66	0.158	5.85	MAR-25-75	4315	5.95	THROMBOEMBOLISM
[illegible]6R17Y	93	3.62	0.180	6.66	APR-24-75	4009	6.44	MAMMARY ADENOCARCINOMA
4107R17Y	93	3.77	0.166	6.14	MAR-16-77	8	0.02	ANESTHESIA ACCIDENT
M108R17Y	88	3.95	0.180	6.66	APR-20-78	5583	8.24	ADENOCARCINOMA,MEDIASTINUM
F109R17Y	90	2.98	0.164	6.07	MAY-23-78	4959	6.72	SPONDYLOSIS, VERTEBRAE; DISC PROTRUSION
F110R17Y	91	2.24	0.160	5.92	JUN-20-78	4733	6.81	MALIGNANT EPULIS
M111R17Y	90	3.39	0.158	5.85	MAY-23-78	5168	7.01	SPONDYLOSIS, VERTEBRAE; DISC PROTRUSION
M001R20	471	8.74	0.382	14.1	APR-20-53	3440	8.71	HEMANGIOSARCOMA (SOFT TISSUE)
M002R20	592	8.21	0.387	14.3	NOV-16-53	3775	6.45	OSTEOSARCOMA, MELANOMA (EYE)
F003R20	541	8.53	0.347	12.8	MAR-10-54	4459	8.97	LYMPHOSARCOMA
M004R20	414	10.5	0.361	13.4	APR-07-54	325	1.90	PERFORATION (ILEUS)
M004R20A	420	10.6	0.306	11.3	APR-11-55	4368	11.8	VALVULAR ENDOCARDITIS, MELANOMA (EYE)
M005R20	461	11.5	0.267	9.88	JUN-22-54	4703	10.2	OSTEOSARCOMA, ADRENAL CORTEX ADENOCARCINOMA
F006R20	486	10.6	0.360	13.3	JUL-27-54	4615	13.0	EPIDERMOID CARCINOMA (TYMPANIC BULLA)
M007R20	514	11.1	0.413	15.3	AUG-24-54	3424	9.52	OSTEOSARCOMA, CUSHING'S DISEASE
F008R20	572	6.95	0.331	12.2	DEC-21-54	4781	10.3	UNDIFFERENTIATED MALIGNANCY (INTESTINE)
F009R20	592	9.38	0.317	11.7	APR-11-55	3998	7.12	MAMMARY ADENOCARCINOMA
M010R20	523	9.95	0.345	12.8	JUL-27-55	3569	12.6	OSTEOSARCOMA
F011R20	495	9.30	0.310	11.5	DEC-20-55	3297	8.56	OSTEOSARCOMA
F012R20	497	10.3	0.281	10.4	JAN-17-56	2948	7.70	MAMMARY ADENOCARCINOMA
M101R20Y	90	4.64	0.317	11.7	MAR-07-75	3022	9.51	OSTEOSARCOMA
M102R20Y	90	4.27	0.324	12.0	MAR-07-75	3492	10.6	OSTEOSARCOMA
M103R20Y	90	5.35	0.320	11.8	MAR-07-75	4135	13.5	PROSTATIC CARCINOMA

B.7 ^{226}Ra, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F104R20Y	90	4.36	0.317	11.7	MAR-07-75	3980	12.0	OSTEOSARCOMA, MAMMARY ADENOCARCINOMA
F105R20Y	90	3.93	0.321	11.9	MAR-07-75	3029	8.73	THROMBOEMBOLISM, INFARCTION
F106R20Y	89	4.19	0.309	11.4	MAR-14-75	3664	10.2	ENDOMETRITIS, NEPHRITIS, PNEUMONIA
M107R20Y	93	4.53	0.329	12.2	MAR-16-77	5930	14.07	THROMBOSIS,PENIS
M108R20Y	88	4.43	0.348	12.9	APR-20-78	3142	9.80	OSTEOSARCOMA
F109R20Y	88	2.79	0.332	12.3	JAN-19-78	5552	12.36	HEMANGIOSARCOMA,LIVER
F110R20Y	90	3.55	0.320	11.8	JUN-20-78	4245	10.05	COMBINED OSTEOSARCOMA, ISCHIUM
M001R30	473	8.91	1.20	44.4	APR-20-53	2850	24.2	OSTEOSARCOMA
M002R30	470	9.02	1.21	44.8	NOV-16-53	2226	17.6	OSTEOSARCOMA
F003R30	386	7.74	1.11	41.1	MAR-10-54	2497	23.7	OSTEOSARCOMA
M004R30	412	11.7	1.16	42.9	APR-07-54	1917	24.0	OSTEOSARCOMA
M005R30	461	13.0	0.846	31.3	JUN-22-54	2955	23.7	OSTEOSARCOMA
F006R30	486	9.75	1.14	42.2	JUL-27-54	1932	22.9	OSTEOSARCOMA
M007R30	514	12.3	1.29	47.7	AUG-24-54	2099	30.9	OSTEOSARCOMA
F008R30	542	7.76	1.03	38.1	DEC-21-54	2612	19.8	OSTEOSARCOMA
F009R30	551	8.02	0.987	36.5	APR-11-55	2487	19.1	OSTEOSARCOMA
M010R30	525	10.1	1.06	39.2	JUL-27-55	1737	23.9	OSTEOSARCOMA
F011R30	495	12.9	0.938	34.7	DEC-20-55	1610	13.9	ENDOMETRITIS, PERITONITIS
F012R30	497	11.4	0.883	32.7	JAN-17-56	1897	17.0	OSTEOSARCOMA
M101R30Y	93	4.41	1.01	37.4	APR-24-75	2965	32.9	EPIDERMOID CARCINOMA (MIDDLE EAR)
M102R30Y	93	5.40	1.01	37.4	APR-24-75	2231	24.3	OSTEOSARCOMA
M103R30Y	90	2.94	1.08	40.0	MAY-06-75	2513	25.9	PATHOLOGICAL FRACTURE
F104R30Y	88	3.74	1.02	37.7	MAR-25-75	2728	27.4	THROMBOEMBOLISM
F105R30Y	93	4.51	1.02	37.7	APR-24-75	2504	25.0	OSTEOSARCOMA
F106R30Y	90	3.25	1.07	39.6	MAY-06-75	2102	26.0	OSTEOSARCOMA
M107R30Y	88	2.46	1.05	38.8	JAN-19-78	2602	27.1	OSTEOSARCOMA
M108R30Y	88	2.34	1.05	38.8	MAY-09-78	3788	32.5	OSTEOSARCOMA, METATARSUS
F109R30Y	93	3.40	1.09	40.3	JAN-19-78	2862	23.3	OSTEOSARCOMA
F110R30Y	94	3.04	1.02	37.7	AUG-08-78	1659	16.7	OSTEOSARCOMA
F501R30+	1787	10.4	0.806	29.8	JUN-10-75	1799	20.8	OSTEOSARCOMA
F502R30+	1918	8.26	0.972	36.0	SEP-22-76	2772	13.4	OSTEOSARCOMA
F503R30+	1836	10.0	1.08	40.0	NOV-29-77	2249	12.2	LYMPHOSARCOMA
F504R30+	1876	9.33	1.02	37.7	OCT-05-78	3322	15.6	THROMBOSIS (LUNG), AMYLOIDOSIS KIDNEY
F505R30+	1815	8.15	1.23	45.5	NOV-02-78	1776	14.1	OSTEOSARCOMA
M506R30+	1868	9.72	1.00	37.0	OCT-05-78	21	0.32	ANESTHESIA ACCIDENT
M507R30+	1881	10.8	1.01	37.4	OCT-05-78	2591	14.7	THROMBOEMBOLISM, OSTEOPOROSIS
M508R30+	1876	11.5	1.01	37.4	OCT-05-78	2086	15.7	PROSTATITIS, NEPHRITIS
M509R30+	1829	11.8	1.23	45.5	NOV-02-78	2035	17.0	FIBROSARCOMA (SKELETON)
M510R30+	1817	10.6	1.23	45.5	NOV-02-78	1671	11.6	OSTEOSARCOMA
M001R40	471	9.08	3.51	130.	APR-20-53	1606	66.1	OSTEOSARCOMA
M002R40	470	9.53	3.55	131.	NOV-16-53	1884	62.4	OSTEOSARCOMA
F003R40	384	8.65	3.33	123.	MAR-10-54	490	22.3	CANINE DISTEMPER
F003R40A	598	7.20	3.10	115.	NOV-30-56	1614	41.0	OSTEOSARCOMA
M004R40	408	8.83	3.47	128.	APR-07-54	1518	61.5	OSTEOSARCOMA

B.7 ^{226}Ra, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M005R40	461	13.2	2.42	89.5	JUN-22-54	1659	45.8	OSTEOSARCOMA
F006R40	486	8.55	3.44	127.	JUL-27-54	1939	72.7	OSTEOSARCOMA
M007R40	453	9.55	3.88	144.	AUG-24-54	1647	59.9	OSTEOSARCOMA
F008R40	474	8.94	3.14	116.	DEC-21-54	1324	47.2	OSTEOSARCOMA
F009R40	542	8.53	3.02	112.	APR-11-55	1471	42.3	OSTEOSARCOMA
M010R40	527	10.8	3.28	121.	JUL-27-55	1553	77.4	OSTEOSARCOMA
F011R40	491	10.4	2.84	105.	DEC-20-55	1469	54.3	OSTEOSARCOMA
F012R40	496	9.61	2.81	104.	JAN-17-56	1435	40.4	OSTEOSARCOMA
F501R40+	1787	10.5	2.50	92.5	JUN-10-75	303	20.8	PERITONITIS
F502R40+	1933	9.09	2.96	110.	SEP-22-76	1674	55.9	OSTEOSARCOMA, HEMOTHORAX
F503R40+	1836	10.9	3.44	127.	NOV-29-77	1521	47.2	OSTEOSARCOMA
F504R40+	1835	7.93	1.98	73.3	JAN-10-78	636	9.80	NEPHRITIS, STATUS EPILEPTICUS
F505R40+	1876	11.6	2.89	107.	OCT-05-78	1380	37.2	CRIPPLING FRACTURE
M506R40+	1881	10.1	2.97	110.	OCT-05-78	1692	41.0	OSTEOSARCOMA, NEPHRITIS
M507R40+	1823	11.2	3.04	112.	MAY-09-78	1462	39.0	NEPHRITIS
M508R40+	1845	10.5	2.99	111.	OCT-05-78	1365	40.4	OSTEOSARCOMA
M509R40+	1817	13.2	3.65	135.	NOV-02-78	952	31.4	LEIOMYOSARCOMA
M510R40+	1807	12.2	3.61	134.	NOV-02-78	516	20.5	NEPHRITIS, CRIPPLING FRACTURE
F511R40+	2254	10.7	3.88	144.	AUG-19-80	1318	43.0	OSTEOSARCOMA, NEPHRITIS
M512R40+	2187	13.7	3.03	112.	AUG-19-80	1680	43.1	OSTEOSARCOMA, NEPHROSIS
F513R40+	2239	10.9	3.20	118.	AUG-19-80	1675	34.1	OSTEOSARCOMA, NEPHROSIS
F514R40+	2022	11.4	3.20	118.	AUG-19-80	1182	33.9	OSTEOSARCOMA
M515R40+	2087	10.0	3.21	119.	SEP-16-80	702	22.8	MAST CELL SARCOMA
M516R40+	2090	13.2	3.21	119.	SEP-16-80	1808	41.1	OSTEOSARCOMA, CHOLANGIOCARCINOMA
M517R40+	2065	12.6	3.17	117.	SEP-16-80	674	19.6	NEPHRITIS
F518R40+	2102	9.87	3.18	118.	SEP-16-80	678	18.2	NEPHRITIS, PNEUMONIA
F519R40+	2090	10.5	3.21	119.	SEP-16-80	1662	36.3	OSTEOSARCOMA
F520R40+	2087	9.43	3.25	120.	SEP-16-80	1323	41.4	OSTEOSARCOMA, NEPHROSIS
M001R50	473	9.87	10.5	389.	APR-20-53	908	150.	OSTEOSARCOMA
M002R50	470	8.85	10.8	400.	NOV-16-53	1380	183.	OSTEOSARCOMA
F003R50	380	7.82	10.1	374.	MAR-10-54	481	72.4	CANINE DISTEMPER
M004R50	408	8.90	10.6	392.	APR-07-54	1091	167.	OSTEOSARCOMA
M005R50	458	10.9	10.1	374.	JUN-22-54	1220	157.	OSTEOSARCOMA
F006R50	486	9.66	10.2	377.	JUL-27-54	1015	157.	OSTEOSARCOMA
M007R50	453	8.85	11.9	440.	AUG-24-54	1288	171.	OSTEOSARCOMA
F008R50	474	7.76	9.68	358.	DEC-21-54	968	119.	OSTEOSARCOMA
F009R50	420	9.16	9.48	351.	APR-11-55	1288	164.	OSTEOSARCOMA, ANEMIA
M010R50	527	10.7	10.2	377.	JUL-27-55	825	115.	OSTEOSARCOMA, CRIPPLING FRACTURE
F501R50+	1827	12.8	10.2	377.	AUG-16-77	266	31.5	NEPHRITIS
F502R50+	1812	9.65	9.97	369.	NOV-29-77	1219	166.	OSTEOSARCOMA
F503R50+	1819	10.8	6.31	233.	JAN-10-78	419	32.5	NEPHRITIS
F504R50+	1855	7.52	9.22	341.	MAY-09-78	420	32.3	NEPHRITIS

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F042R00B WAS REMOVED FROM INJECTION TABLES BECAUSE DOG NEVER REACHED YOUNG ADULT AGE.

B.8 ^{228}Ra (Mesothorium), Chronic Toxicity Study

DOG NUMBER	AGE (DAYS)	WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F001M00	732	7.33			JAN-04-54	3451		MENINGOENCEPHALITIS
F002M00	545	6.94			NOV-29-54	6155		SENILITY
M003M00	579	13.0			MAR-13-56	5056		INFARCTION (BRAIN)
M004M00	601	10.3			JAN-15-57	4816		VALVULAR ENDOCARDITIS MYOCARDIAL INFARCTION
F005M00	670	11.2			MAR-05-57	4581		MAMMARY ADENOCARCINOMA
M006M00	492	7.56			APR-23-57	4934		NEPHRITIS
F007M00	395	8.71			JUN-04-57	1414		STATUS EPILEPTICUS
F007M00A	594	10.9			JAN-15-63	3624		PNEUMONIA
F008M00	654	11.6			MAR-09-60	5009		THROMBOEMBOLISM
M009M00	575	12.4			APR-13-60	4132		PNEUMONIA
M010M00	581	13.3			JUL-17-62	2991		MELANOMA (MOUTH)
F011M00	475	9.31			SEP-18-62	3248		PNEUMONIA
M012M00	695	10.0			DEC-22-60	4810		THROMBOEMBOLISM,TRANS. CELL CARC. (URINARY BLADDER)
F001M05	492	9.47	0.0173	0.640	JUL-17-62	5460	0.70	THROMBOEMBOLISM, MELANOMA (EYE)
F002M05	492	9.15	0.0173	0.640	JUL-17-62	3689	0.94	PANCREATITIS
M003M05	493	10.8	0.0199	0.736	SEP-18-62	4697	1.13	THROMBOEMBOLISM, MELANOMA (EYE)
M004M05	475	12.8	0.0199	0.736	SEP-18-62	4193	1.20	LYMPHOSARCOMA
F005M05	534	7.83	0.0172	0.636	OCT-23-62	3958	0.81	LYMPHOSARCOMA
M006M05	510	10.3	0.0171	0.633	OCT-23-62	3019	0.71	MELANOMA (EYE)
F007M05	492	8.87	0.0172	0.636	JUL-17-62	4997	1.12	PNEUMONIA, MELANOMA (EYE)
F008M05	654	12.6	0.0159	0.588	MAR-09-60	4205	0.70	ENTERITIS, MELANOMA (EYE)
M009M05	485	11.9	0.0170	0.629	APR-13-60	5321	1.06	THROMBOEMBOLISM
M010M05	492	10.6	0.0174	0.644	JUL-17-62	4567	1.11	DEGENERATION (KIDNEY),THROMBOEMBOLISM, MELANOMA (EYE)
F011M05	505	7.82	0.0202	0.747	SEP-18-62	4033	1.06	BILIARY OBSTRUCTION, MELANOMA (EYE)
M012M05	510	10.6	0.0165	0.611	OCT-23-62	3920	0.84	STATUS EPILEPTICUS
F001M10	718	7.75	0.0463	1.71	JAN-04-54	2952	1.88	FIBROSARCOMA (SPLEEN)
F001M10A	590	8.07	0.0512	1.89	OCT-23-62	4292	2.19	NEPHRITIS,MELANOMA (EYE),PANCREATITIS,CHOLANGIOCARC.
F002M10	459	8.25	0.0324	1.20	NOV-29-54	5267	2.13	FIBROSARCOMA, GINGIVAL (R.MAXILLA), MELANOMA (EYE)
M003M10	575	13.8	0.0589	2.18	MAR-13-56	3157	3.06	OSTEOSARCOMA
M004M10	601	9.90	0.0481	1.78	JAN-15-57	4260	1.31	PNEUMONIA, PANCREATITIS, MELANOMA (EYE)
F005M10	658	8.80	0.0490	1.81	MAR-05-57	4565	1.92	MELANOMA (EYE)
M006M10	492	10.6	0.0468	1.73	APR-23-57	3402	2.73	EPIDERMOID CARCINOMA (PENIS)
F007M10	534	9.89	0.0489	1.81	JUN-04-57	2159	1.50	HEMANGIOSARCOMA
F008M10	654	12.4	0.0491	1.82	MAR-09-60	3886	2.41	MELANOMA (EYE)
M009M10	485	10.1	0.0504	1.86	APR-13-60	4670	3.12	VALVULAR ENDOCARDITIS
M010M10	492	9.43	0.0501	1.85	JUL-17-62	2966	2.13	MELANOMA (EYE)
F011M10	505	8.91	0.0613	2.27	SEP-18-62	4943	4.05	MAMMARY ADENOCARCINOMA
M012M10	528	9.27	0.0498	1.84	OCT-23-62	3786	2.32	LYMPHOSARCOMA
F001M17	510	7.52	0.151	5.59	OCT-23-62	4265	7.21	OSTEOSARCOMA
F002M17	560	9.90	0.183	6.77	MAR-13-56	2383	7.32	OSTEOSARCOMA
M003M17	576	11.0	0.180	6.66	MAR-13-56	2709	7.21	OSTEOSARCOMA
M004M17	601	8.94	0.143	5.29	JAN-15-57	2864	4.26	LYMPHOSARCOMA
F005M17	658	12.8	0.141	5.22	MAR-05-57	3234	6.29	OSTEOSARCOMA

B.8 ^{228}Ra (Mesothorium), Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M006M17	492	10.0	0.144	5.33	APR-23-57	3424	3.96	OSTEOSARCOMA
F007M17	534	10.2	0.146	5.40	JUN-04-57	2646	6.04	OSTEOSARCOMA, MELANOMA (EYE)
F008M17	654	10.8	0.148	5.48	MAR-09-60	2486	3.88	OSTEOSARCOMA
M009M17	485	12.6	0.149	5.51	APR-13-60	2799	6.86	OSTEOSARCOMA
M010M17	492	10.1	0.124	4.59	JUL-17-62	3101	7.53	OSTEOSARCOMA
F011M17	505	10.7	0.179	6.62	SEP-18-62	3325	10.1	OSTEOSARCOMA
M012M17	524	9.28	0.153	5.66	OCT-23-62	3017	7.23	UNDETERMINED (NO SKELETAL TUMOR)
F001M20	676	7.60	0.276	10.2	JAN-04-54	1780	8.28	OSTEOSARCOMA, MELANOMA (EYE)
F002M20	517	8.25	0.194	7.18	NOV-29-54	965	1.94	HEMORRHAGE (INTESTINE)
M003M20	576	11.0	0.358	13.2	MAR-13-56	619	3.27	PNEUMONIA
M004M20	601	9.88	0.282	10.4	JAN-15-57	2282	10.4	OSTEOSARCOMA
F005M20	508	8.30	0.295	10.9	MAR-05-57	2688	9.32	OSTEOSARCOMA
M006M20	501	12.4	0.306	11.3	APR-23-57	2674	13.9	OSTEOSARCOMA
F007M20	534	10.1	0.298	11.0	JUN-04-57	2239	10.7	PANCREATITIS
F008M20	654	12.4	0.300	11.1	MAR-09-60	2386	9.32	OSTEOSARCOMA
M009M20	630	9.99	0.302	11.2	APR-13-60	1254	5.63	OSTEOSARCOMA
M010M20	430	11.2	0.311	11.5	JUL-17-62	2373	14.6	OSTEOSARCOMA
F011M20	505	7.03	0.381	14.1	SEP-18-62	2878	11.0	OSTEOSARCOMA
M012M20	524	9.47	0.306	11.3	OCT-23-62	2471	13.3	OSTEOSARCOMA
F001M30	519	10.4	0.858	31.7	JAN-04-54	918	17.3	OSTEOSARCOMA
F002M30	460	6.70	0.612	22.6	NOV-29-54	1856	20.7	OSTEOSARCOMA
M003M30	579	10.4	0.965	35.7	MAR-13-56	1185	24.5	OSTEOSARCOMA
M004M30	601	10.2	0.916	33.9	JAN-15-57	1176	15.9	OSTEOSARCOMA
F005M30	531	8.51	0.940	34.8	MAR-05-57	1869	21.6	OSTEOSARCOMA
M006M30	501	9.09	0.953	35.3	APR-23-57	1421	19.1	OSTEOSARCOMA
F007M30	534	9.94	0.907	33.6	JUN-04-57	1463	31.6	OSTEOSARCOMA
F008M30	633	11.8	0.950	35.1	MAR-09-60	1447	21.7	OSTEOSARCOMA
M009M30	630	9.83	0.918	34.0	APR-13-60	1570	22.9	OSTEOSARCOMA
M010M30	581	10.4	1.00	37.0	JUL-17-62	1575	23.3	OSTEOSARCOMA
F011M30	499	11.0	1.19	44.0	SEP-18-62	1395	24.7	OSTEOSARCOMA
M012M30	510	12.9	0.987	36.5	OCT-23-62	1638	23.8	OSTEOSARCOMA
F001M40	509	7.56	2.60	96.2	JAN-04-54	841	53.9	OSTEOSARCOMA, CRIPPLING FRACTURE
F002M40	460	6.95	1.86	68.8	NOV-29-54	778	22.3	OSTEOSARCOMA
M003M40	579	9.65	3.37	125.	MAR-13-56	418	17.3	STRANGULATED HERNIA
M003M40A	494	7.34	2.64	97.7	JUN-04-57	1063	56.2	OSTEOSARCOMA, NEPHRITIS, ULCER (MOUTH)
M004M40	609	7.84	2.47	91.4	JAN-15-57	896	26.8	CRIPPLING FRACTURE, ULCER (MOUTH)
F005M40	508	9.63	2.67	98.8	MAR-05-57	1064	43.6	OSTEOSARCOMA
M006M40	501	9.49	2.66	98.4	APR-23-57	1121	47.9	OSTEOSARCOMA
F007M40	543	8.40	2.67	98.8	JUN-04-57	1253	46.5	OSTEOSARCOMA
F001M50	493	7.77	8.11	300.	JAN-04-54	232	34.3	NEPHRITIS, ANEMIA
F002M50	460	7.35	5.46	202.	NOV-29-54	780	75.5	CRIPPLING FRACTURE
M003M50	579	8.87	10.4	385.	MAR-13-56	688	140.	ULCER (MOUTH)
M004M50	482	7.29	7.89	292.	JAN-15-57	561	56.3	CRIPPLING FRACTURE

B.8 ^{228}Ra (Mesothorium), Chronic Toxicity Study (continued)

DOG NUMBER	AGE (DAYS)	WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F005M50	658	11.1	8.48	314.	MAR-05-57	770	95.4	ULCER (MOUTH)
M006M50	580	7.53	8.67	321.	APR-23-57	792	67.3	OSTEOSARCOMA, CRIPPLING FRACTURE
F007M50	494	7.35	8.92	330.	JUN-04-57	966	181.	ULCER (MOUTH), MYOCARDIAL INFARCTION

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(KBQ TH-228/KBQ RA-228) INJECTED = 0.15 FOR F001M10, F001M20, F001M30, F001M40, F001M50.

= 0.03 FOR F002M10, F002M17, F002M20, F002M30, F002M40, F002M50
M003M10, M003M17, M003M20, M003M30, M003M40, M003M50.

= 0.006 FOR GROUPS 4, 5, 6, 7, 8, 9, 10, 11, 12, AND FOR DOGS
F001M05, F002M05, M003M05, F001M10A, F001M17, M003M40A.

B.9 ^{90}Sr, Chronic Toxicity Study

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F001S00	502	8.48			JAN-18-55	5484		PANCREAS ADENOCARCINOMA
M002S00	600	11.1			FEB-14-56	3838		LUNG CARCINOMA
M003S00	493	9.03			SEP-11-57	3516		OBTURATING AORTIC EMBOLISM, NEPHRITIS
F004S00	520	8.19			OCT-15-57	5755		NEPHRITIS, SENILITY
M005S00	542	10.6			NOV-19-57	4158		TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M006S00	466	9.68			MAY-27-58	4726		MELANOMA (MOUTH)
F007S00A	462	9.46			JAN-07-59	3303		DIABETES MELLITUS
F008S00	483	9.29			MAY-19-59	4482		DIABETES MELLITUS
F009S00	549	12.4			AUG-11-59	708		TRAUMA
F009S00A	535	11.2			JUN-04-63	3425		MAMMARY ADENOCARCINOMA
M010S00	522	13.9			SEP-29-59	4977		FIBROMA (SOFT TISSUE)
F011S00	541	9.60			NOV-03-59	4831		MAMMARY ADENOCARCINOMA
M012S00	605	8.99			JAN-06-60	5374		CARCINOMA (INTESTINE), SENILITY
F001S10	1524	6.84	0.573	21.2	JAN-18-55	308	0.20	IMPROPER INJECTION AGE
F001S10A	521	9.38	0.588	21.8	FEB-14-56	5219	0.90	THROMBOEMBOLISM
M002S10	567	8.81	0.606	22.4	FEB-14-56	5077	0.90	AORTIC BODY TUMOR
M003S10	493	10.9	0.572	21.2	SEP-11-57	5363	1.42	EPIDERMOID CARCINOMA (MOUTH)
F004S10	525	8.96	0.560	20.7	OCT-15-57	5902	1.48	NEPHRITIS, MAMMARY ADENOCARCINOMA
M005S10	555	10.2	0.532	19.7	NOV-19-57	2705	0.70	STATUS EPILEPTICUS
M006S10	466	9.56	0.581	21.5	MAY-27-58	5739	2.20	LYMPHOSARCOMA
F007S10	524	9.94	0.517	19.1	NOV-11-58	5837	1.21	LYMPHOSARCOMA, MAMMARY ADENOCARCINOMA
F008S10	483	10.8	0.697	25.8	MAY-19-59	2784	0.78	ISLET CELL, ADENOCARCINOMA
F009S10	549	11.6	0.534	19.8	AUG-11-59	3601	0.87	PNEUMONIA, ENTERITIS
M010S10	522	11.5	0.558	20.6	SEP-29-59	5321	1.20	SEBACEOUS GLAND ADENOCARCINOMA
F011S10	543	10.3	0.550	20.4	NOV-03-59	4944	1.06	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M012S10	607	13.7	0.559	20.7	JAN-06-60	4184	0.95	BILIARY OBSTRUCTION
F001S17	526	7.41	1.78	65.9	FEB-14-56	5624	4.72	HEMANGIOENDOTHELIAL SARCOMA (LIVER)
M002S17	567	11.6	1.84	68.1	FEB-14-56	4297	4.07	HEMORRHAGE (SOFT TISSUE)
M003S17	493	9.19	1.69	62.5	SEP-11-57	4846	3.37	THROMBOEMBOLISM
F004S17	522	9.60	1.68	62.2	OCT-15-57	4629	2.96	PANCREAS ADENOCARCINOMA
M005S17	560	9.85	1.60	59.2	NOV-19-57	1715	1.64	COMA (NO SKELETAL TUMOR)
M005S17A	493	11.4	1.78	65.9	MAR-06-63	5379	5.73	SENILITY
M006S17	466	10.6	1.72	63.6	MAY-27-58	5581	5.43	TRANSITIONAL CELL CARC. (URINARY BLADDER),NEPHROSIS
F007S17	488	10.2	1.60	59.2	NOV-11-58	3990	2.47	ARTHRITIS, MAMMARY ADENOCARCINOMA
F008S17	472	8.47	2.03	75.1	MAY-19-59	1973	2.13	STATUS EPILEPTICUS, PANCREATITIS
F009S17	549	10.0	1.62	59.9	AUG-11-59	4803	4.13	LYMPHOSARCOMA, NEPHRITIS
M010S17	519	13.6	1.66	61.4	SEP-29-59	2947	3.04	THROMBOEMBOLISM, NEPHRITIS LUNG
F011S17	543	11.0	1.68	62.2	NOV-03-59	3180	2.38	THROMBOEMBOLISM, CALCIFICATION (LUNG)
M012S17	607	11.9	1.68	62.2	JAN-06-60	4717	3.55	ISLET CELL TUMOR
F001S20	502	5.59	3.70	137.	JAN-18-55	3269	4.75	PNEUMONIA
M002S20	567	8.97	3.42	127.	FEB-14-56	3768	6.29	LYMPHOSARCOMA, LUNG CARCINOMA
M003S20	494	7.82	3.39	125.	SEP-11-57	4295	6.68	STATUS EPILEPTICUS, THYROID CARCINOMA
F004S20	522	9.68	3.41	126.	OCT-15-57	4775	7.35	MAMMARY ADENOCARCINOMA

B.9 ^{90}Sr, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M005S20	560	8.72	3.24	120.	NOV-19-57	3253	5.28	ULCER (STOMACH)
M006S20	466	9.19	3.50	130.	MAY-27-58	5193	8.47	UNDIFFERENTIATED SARCOMA (LIVER), NEPHRITIS
F007S20	488	11.2	3.19	118.	NOV-11-58	3421	4.55	ISLET CELL ADENOMA
F008S20	465	9.49	4.14	153.	MAY-19-59	3955	6.83	PNEUMONIA
F009S20	473	14.1	3.28	121.	AUG-11-59	2467	5.62	UNDETERMINED (NO SKELETAL TUMOR)
M010S20	508	10.7	3.34	124.	SEP-29-59	3436	5.91	VALVULAR ENDOCARDITIS
F011S20	543	10.4	3.41	126.	NOV-03-59	4880	6.58	MAMMARY SARCOMA
M012S20	607	11.6	3.49	129.	JAN-06-60	4584	7.06	HEPATIC CELL CARCINOMA
F001S30	468	7.36	11.6	429.	JAN-18-55	5149	32.9	UNDETERMINED (NO SKELETAL TUMOR)
M002S30	564	9.62	11.6	429.	FEB-14-56	4263	26.0	NEPHRITIS
M003S30	494	11.4	10.8	400.	SEP-11-57	4947	24.0	SEMINOMA, HYDROCEPHALUS
F004S30	527	9.17	10.6	392.	OCT-15-57	3101	14.8	MAMMARY ADENOCARCINOMA
M005S30	557	8.90	10.1	374.	NOV-19-57	4640	21.3	SERTOLI CELL TUMOR
M006S30	466	9.44	10.9	403.	MAY-27-58	5667	30.8	NEPHRITIS, MALIGNANCY (TESTES)
F007S30	486	9.80	10.1	374.	NOV-11-58	4018	18.1	OSTEOSARCOMA,MAMMARY ADENOCARCINOMA,THYROID CARCINOMA
F008S30	465	12.5	12.9	477.	MAY-19-59	4832	30.5	UNDETERMINED (NO SKELETAL TUMOR)
F009S30	468	10.0	10.1	374.	AUG-11-59	4599	26.6	CHROMOPHOBE ADENOMA
M010S30	519	12.5	10.3	381.	SEP-29-59	2898	20.9	FIBROSARCOMA (SOFT TISSUE)
F011S30	541	9.00	10.8	400.	NOV-03-59	4831	9.54	NEPHRITIS
M012S30	605	8.43	10.2	377.	JAN-06-60	4831	16.3	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
F001S40	468	8.74	33.3	1230.	JAN-18-55	3682	65.9	UNDETERMINED (NO SKELETAL TUMOR)
M002S40	567	11.2	32.6	1210.	FEB-14-56	2093	56.4	EPIDERMOID CARCINOMA (MOUTH)
M003S40	593	9.83	32.1	1190.	SEP-11-57	2781	41.2	THROMBOEMBOLISM
F004S40	528	8.24	32.1	1190.	OCT-15-57	4844	77.7	OSTEOSARCOMA, EPIDERMOID CARCINOMA (MOUTH)
M005S40	562	9.65	30.6	1130.	NOV-19-57	4427	62.6	HEMANGIOSARCOMA (SOFT TISSUE)
M006S40	504	16.0	32.7	1210.	SEP-03-58	3530	68.7	SEMINOMA
F007S40	478	10.9	30.9	1140.	NOV-11-58	4664	79.0	OSTEOSARCOMA
F008S40	465	10.9	40.6	1500.	MAY-19-59	2206	77.1	UNDETERMINED (NO SKELETAL TUMOR)
F009S40	468	9.56	30.6	1130.	AUG-11-59	4942	75.9	UNDETERMINED (NO SKELETAL TUMOR)
M010S40	517	8.20	31.3	1160.	SEP-29-59	4242	63.5	HEMANGIOMA, PERIANAL GLAND CARCINOMA
F011S40	542	8.86	32.7	1210.	NOV-03-59	2114	33.0	BLOOD DYSCRASIA, ENDOMETRITIS
M012S40	605	10.9	32.3	1200.	JAN-06-60	4226	52.8	NOSE ADENOCARCINOMA
F001S45	529	9.00	64.2	2380.	MAR-16-66	3030	73.7	PURPURA HEMORRHAGICA
M002S45	529	12.2	63.6	2350.	MAR-16-66	2707	72.2	OSTEOSARCOMA
M003S45	529	11.9	63.8	2360.	MAR-16-66	1493	58.9	ANEMIA, INFARCTION, MYELOID METAPLASIA
F004S45	529	9.80	64.5	2390.	MAR-16-66	2197	90.4	HEMANGIOSARCOMA (SOFT TISSUE)
M005S45	496	13.3	61.3	2270.	MAR-16-66	993	53.5	OSTEOSARCOMA
M006S45	496	12.0	63.8	2360.	MAR-16-66	2843	94.3	OSTEOSARCOMA
F007S45	510	9.90	64.5	2390.	MAR-16-66	2813	100.	OSTEOSARCOMA, EPIDERMOID CARCINOMA (FRONTAL SINUS)
F008S45	510	9.90	64.5	2390.	MAR-16-66	2325	94.8	HEMANGIOSARCOMA (SKELETON)
F009S45	510	10.3	64.0	2370.	MAR-16-66	1028	51.3	OSTEOSARCOMA
M010S45	496	14.0	60.9	2250.	MAR-16-66	2064	110.	EPIDERMOID CARCINOMA (FRONTAL SINUS)
F011S45	496	11.9	63.8	2360.	MAR-16-66	1758	63.8	OSTEOSARCOMA

B.9 ^{90}Sr, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M012S45	485	11.4	63.7	2360.	MAR-16-66	2253	97.7	OSTEOSARCOMA, HEMANGIOSARCOMA (SKELETON)
F001S50	434	9.38	103.	3810.	JAN-18-55	960	82.6	OSTEOSARCOMA
M002S50	551	12.2	102.	3770.	FEB-14-56	255	30.9	STRANGULATED HERNIA
M002S50A	545	11.4	96.6	3570.	JAN-07-59	1740	122.	OSTEOSARCOMA
M003S50	507	10.3	102.	3770.	OCT-15-57	2256	164.	OSTEOSARCOMA
F004S50	528	11.4	105.	3890.	OCT-15-57	1448	94.2	OSTEOSARCOMA
M005S50	621	8.53	95.2	3520.	NOV-19-57	1285	101.	ANEMIA, AUTOAGGLUTINATION, INFARCTION
M006S50	504	9.33	98.8	3660.	SEP-03-58	35	5.23	HEMORRHAGE (INTESTINE)
M006S50A	462	11.2	94.2	3490.	JAN-07-59	1021	114.	OSTEOSARCOMA, INFARCTION, THROMBOCYTOPENIA
F007S50	478	10.2	92.7	3430.	NOV-11-58	1129	108.	STATUS EPILEPTICUS
F008S50	535	11.2	90.5	3350.	JAN-07-59	1469	110.	OSTEOSARCOMA
F009S50	459	8.82	93.5	3460.	AUG-11-59	1982	135.	EPIDERMOID CARCINOMA (FRONTAL SINUS)
M010S50	517	8.55	95.9	3550.	SEP-29-59	990	75.4	ANEMIA, THROMBOCYTOPENIA
F011S50	542	8.97	102.	3770.	NOV-03-59	1667	99.2	HEMANGIOSARCOMA (SKELETON)
M012S50	606	12.5	99.2	3670.	JAN-06-60	1165	80.3	HEMANGIOSARCOMA (SKELETON)

B.10 ^{228}Th, Chronic Toxicity Study

DOG NUMBER	AGE (DAYS)	WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
M001T00	493	8.24			FEB-08-54	4895		LYMPHOSARCOMA
M002T00	488	7.28			SEP-28-54	5510		INTERSTITIAL NEPHRITIS
F003T00	797	11.6			JUN-06-55	2592		BRAIN HEMORRHAGE
M004T00	591	8.10			OCT-18-55	3072		LYMPHOSARCOMA
M005T00	458	10.4			OCT-14-58	5306		LYMPHOSARCOMA
F006T00	489	9.64			JAN-10-61	171		TRAUMA
F006T00A	688	8.61			DEC-15-60	4549		PERICARDITIS
M007T00	517	10.5			FEB-07-61	1412		HEMORRHAGE (BRAIN)
M008T00	533	10.8			MAY-24-61	4963		NEPHRITIS
F009T00	569	8.28			JUN-29-61	5061		TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
F010T00	536	10.4			JUL-28-61	4700		AORTIC BODY TUMOR
F011T00	530	9.45			JUN-04-63	4271		STATUS EPILEPTICUS
F012T00	492	9.09			JUL-09-63	4137		TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
M001T02	682	11.4	0.00164	0.0607	MAR-27-62	4837	0.13	LUNG CARCINOMA, MYELOID SARCOMA (LIVER)
M002T02	682	10.4	0.00166	0.0614	MAR-27-62	4822	0.13	MELANOMA (MOUTH), STOMACH CARCINOMA
F003T02	478	9.86	0.00163	0.0603	MAR-27-62	4720	0.13	STATUS EPILEPTICUS
M004T02	478	10.0	0.00166	0.0614	MAR-27-62	4515	0.13	TRANS. CELL CARC. (URINARY BLADDER),THROMBOEMBOLISM
M005T02	625	13.8	0.00162	0.0599	FEB-09-60	889	0.08	STRANGULATION ON VOMITUS, STATUS EPILEPTICUS
M005T02A	530	13.4	0.00173	0.0640	JUN-04-63	5609	0.14	SENILITY
F006T02	489	8.85	0.00176	0.0651	JAN-10-61	4767	0.14	ISLET CELL TUMOR
M007T02	532	10.5	0.00159	0.0588	FEB-07-61	3897	0.12	LYMPHOSARCOMA
M008T02	494	13.9	0.00189	0.0699	MAY-24-61	4826	0.15	LEIOMYOSARCOMA
F009T02	569	7.82	0.00171	0.0633	JUN-29-61	3897	0.13	THROMBOEMBOLISM
F010T02	508	10.5	0.00170	0.0629	JUL-28-61	4217	0.13	BILIARY OBSTRUCTION, MAMMARY ADENOCARCINOMA
F011T02	530	9.76	0.00171	0.0633	JUN-04-63	4573	0.14	BILIARY OBSTRUCTION, CHRONIC PANCREATITIS
F012T02	492	7.37	0.00190	0.0703	JUL-09-63	3350	0.15	HEPATIC CELL CARCINOMA
M001T05	699	14.3	0.00496	0.184	SEP-07-56	3471	0.39	HEMORRHAGE (BRAIN)
M002T05	455	10.5	0.00490	0.181	SEP-28-54	1976	0.35	STRANGULATION ON VOMITUS, STATUS EPILEPTICUS
F003T05	659	8.59	0.00485	0.179	JUN-06-55	3032	0.37	ENDOMETRITIS, PERITONITIS
M004T05	516	8.58	0.00540	0.200	OCT-18-55	2159	0.39	STATUS EPILEPTICUS, PNEUMONIA
M005T05	513	8.46	0.00522	0.193	OCT-14-58	4856	0.41	PROSTATITIS
F006T05	489	9.66	0.00510	0.189	JAN-10-61	4548	0.40	ISLET CELL TUMOR
M007T05	532	9.11	0.00491	0.182	FEB-07-61	5840	0.39	NEPHRITIS, PROSTATE ADENOCARCINOMA
M008T05	533	9.53	0.00562	0.208	MAY-24-61	4599	0.44	MELANOMA (ORAL)
F009T05	569	8.62	0.00529	0.196	JUN-29-61	4149	0.42	MAMMARY ADENOCARCINOMA
F010T05	508	10.2	0.00510	0.189	JUL-28-61	4947	0.40	OSTEOSARCOMA, THYROID ADENOCARCINOMA
F011T05	530	7.78	0.00518	0.192	JUN-04-63	3952	0.41	THROMBOEMBOLISM, ISLET CELL ADENOCARCINOMA
F012T05	492	9.94	0.00567	0.210	JUL-09-63	1682	0.39	DEGENERATION (LIVER), ANESTHESIA ACCIDENT
M001T10	493	9.36	0.0140	0.518	FEB-08-54	3172	1.13	OSTEOSARCOMA
M002T10	699	9.27	0.0146	0.540	SEP-07-56	4570	1.15	PERIANAL GLAND CARCINOMA
F003T10	723	8.84	0.0145	0.537	SEP-07-56	4142	1.14	MYELOID SARCOMA (LIVER)
M004T10	699	8.27	0.0146	0.540	SEP-07-56	3217	1.13	OSTEOSARCOMA, ADENOCARCINOMA (THYROID+PERIANAL GLAND)
M005T10	513	11.9	0.0146	0.540	OCT-14-58	2886	1.12	STATUS EPILEPTICUS

B.10 ^{228}Th, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F006T10	489	8.81	0.0150	0.555	JAN-10-61	3273	1.17	PERFORATION (STOMACH)
M007T10	532	9.18	0.0147	0.544	FEB-07-61	3538	1.15	OSTEOSARCOMA
M008T10	533	8.69	0.0166	0.614	MAY-24-61	5298	1.32	LUNG CARCINOMA, NEPHRITIS
F009T10	527	10.0	0.0160	0.592	JUN-29-61	2546	1.20	LEIOMYOSARCOMA
F010T10	508	10.2	0.0150	0.555	JUL-28-61	3420	1.17	FIBROSARCOMA (BONE)
F011T10	520	7.55	0.0154	0.570	JUN-04-63	4034	1.21	OSTEOSARCOMA
F012T10	471	9.96	0.0167	0.618	JUL-09-63	1263	1.01	PNEUMONIA
M001T15	699	7.95	0.0289	1.07	SEP-07-56	2894	2.22	OSTEOSARCOMA
M002T15	458	10.0	0.0293	1.08	SEP-28-54	2576	2.21	OSTEOSARCOMA
F003T15	609	10.3	0.0303	1.12	JUN-06-55	1921	2.14	COMA (NO SKELETAL TUMOR)
M004T15	591	8.59	0.0299	1.11	OCT-18-55	2309	2.21	HEMANGIOSARCOMA
M005T15	598	9.65	0.0286	1.06	FEB-09-60	1624	1.92	OSTEOSARCOMA
F006T15	489	8.14	0.0292	1.08	JAN-10-61	2373	2.17	OSTEOSARCOMA
M007T15	517	8.83	0.0292	1.08	FEB-07-61	383	0.78	LEPTOSPIROSIS
M007T15A	520	9.08	0.0311	1.15	JUN-04-63	3110	2.40	OSTEOSARCOMA, PNEUMONIA
M008T15	494	11.6	0.0324	1.20	MAY-24-61	2665	2.46	OSTEOSARCOMA
F009T15	527	8.80	0.0306	1.13	JUN-29-61	2983	2.35	CHONDROSARCOMA
F010T15	508	11.6	0.0296	1.10	JUL-28-61	1859	2.08	OSTEOSARCOMA
F011T15	518	11.4	0.0305	1.13	JUN-04-63	2408	2.27	OSTEOSARCOMA
F012T15	464	7.56	0.0329	1.22	JUL-09-63	2120	2.39	OSTEOSARCOMA
M001T20	490	10.2	0.0976	3.61	FEB-08-54	1282	5.97	OSTEOSARCOMA
M002T20	483	9.16	0.0875	3.24	SEP-28-54	1234	5.26	OSTEOSARCOMA
F003T20	474	7.87	0.0908	3.36	JUN-06-55	1541	5.99	OSTEOSARCOMA
M004T20	552	13.0	0.0900	3.33	OCT-18-55	78	0.52	TRAUMA
M004T20A	650	10.6	0.0899	3.33	SEP-07-56	1222	5.37	OSTEOSARCOMA
M005T20	598	9.12	0.0848	3.14	FEB-09-60	1085	4.78	OSTEOSARCOMA
F006T20	451	8.65	0.0879	3.25	JAN-10-61	1108	5.01	OSTEOSARCOMA
M007T20	517	8.85	0.0881	3.26	FEB-07-61	1015	4.79	OSTEOSARCOMA
M008T20	533	10.7	0.0981	3.63	MAY-24-61	1078	5.51	OSTEOSARCOMA
F009T20	527	8.09	0.0979	3.62	JUN-29-61	1209	5.82	OSTEOSARCOMA
F010T20	507	10.7	0.0919	3.40	JUL-28-61	1022	5.02	OSTEOSARCOMA
F011T20	518	10.8	0.0904	3.34	JUN-04-63	1038	4.98	OSTEOSARCOMA
F012T20	463	8.92	0.100	3.70	JUL-09-63	1449	6.44	OSTEOSARCOMA
M001T30	314	9.15	0.301	11.1	FEB-08-54	988	16.9	OSTEOSARCOMA, ANEMIA
M002T30	458	11.9	0.301	11.1	SEP-28-54	859	15.6	GIANT CELL TUMOR, (BONE) TRAUMA
F003T30	471	12.0	0.272	10.1	JUN-06-55	547	10.2	OSTEOSARCOMA
M004T30	606	9.69	0.285	10.5	OCT-18-55	801	14.1	OSTEOSARCOMA
M005T30	571	10.7	0.269	9.95	FEB-09-60	890	14.2	OSTEOSARCOMA
F006T30	451	8.83	0.282	10.4	JAN-10-61	1156	17.2	OSTEOSARCOMA
M007T30	427	9.90	0.266	9.84	FEB-07-61	861	13.8	OSTEOSARCOMA
M008T30	494	10.1	0.313	11.6	MAY-24-61	685	13.9	OSTEOSARCOMA
F009T30	511	11.5	0.298	11.0	JUN-29-61	1062	17.4	OSTEOSARCOMA
F010T30	507	9.26	0.280	10.4	JUL-28-61	971	15.6	OSTEOSARCOMA

B.10 ^{228}Th, Chronic Toxicity Study (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
F011T30	518	10.3	0.290	10.7	JUN-04-63	826	14.6	OSTEOSARCOMA
F012T30	458	11.5	0.320	11.8	JUL-09-63	804	15.9	HEMANGIOSARCOMA (SKELETON)
M001T40	479	8.32	0.882	32.6	FEB-08-54	645	38.9	OSTEOSARCOMA, CRIPPLING FRACTURE
M002T40	458	8.32	0.916	33.9	SEP-28-54	833	48.1	OSTEOSARCOMA, CRIPPLING FRACTURE, NEPHRITIS
F003T40	460	7.25	0.800	29.6	JUN-06-55	763	39.7	ULCER (MOUTH), NEPHRITIS
M004T40	606	8.81	0.835	30.9	OCT-18-55	793	42.5	ULCER (MOUTH)
M001T50	479	9.48	2.76	102.	FEB-08-54	212	45.7	KIDNEY DEGENERATION
M002T50	483	8.22	2.63	97.3	SEP-28-54	97	19.7	PANCYTOPENIA

B.11 ^{241}Am, Test Studies

DOG NUMBER	AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T158M00	553	12.9			DEC-30-76	4292		SPECIAL STUDY
T159M00	546	10.6			DEC-30-76	3555		SPECIAL STUDY
T160M10	577	11.4	0.0159	0.588	DEC-30-76	4408	0.63	FIBROSARCOMA (LIVER)
T161M10	546	11.9	0.0159	0.588	DEC-30-76	1802	0.26	PNEUMONIA
T162M10	546	9.64	0.0164	0.607	DEC-30-76	3770	0.57	CHOLANGIOCARCINOMA
T163M10	544	9.32	0.0162	0.599	DEC-30-76	4863	0.88	SPECIAL STUDY
T164M17	553	11.3	0.0481	1.78	DEC-30-76	3366	1.69	CHOLANGIOCARCINOMA, HEPATIC CELL CARCINOMA
T165M17	546	8.73	0.0488	1.81	DEC-30-76	1810	0.84	PNEUMONIA
T166M17	544	9.28	0.0480	1.78	DEC-30-76	3452	1.59	SPECIAL STUDY
T167M17	544	9.04	0.0482	1.78	DEC-30-76	3340	1.69	CHOLANGIOCARCINOMA
T102M30	515	11.6	0.280	10.4	OCT-10-72	17	0.05	SPECIAL STUDY
T103M30	501	10.6	0.283	10.5	OCT-10-72	2535	6.27	OSTEOSARCOMA,HEMANGIOSARC. (LIVER),FIBROSARC. (LIVER)
T104M30	2658	7.67	0.305	11.3	NOV-28-72	1864	5.18	EMPYEMA
T105M30	2225	7.78	0.301	11.1	NOV-28-72	1100	4.77	FIBROSARCOMA (SOFT TISSUE), DEGENERATION (KIDNEY)
T106M30	2225	13.8	0.308	11.4	NOV-28-72	1909	5.84	TRAUMA
T108M30	507	12.6	0.304	11.2	AUG-08-73	3673	1.08	ENDOMETRITIS, SEPTICEMIA
T109M30	506	9.90	0.306	11.3	AUG-08-73	3960	2.63	PNEUMONIA
T110M30	506	9.30	0.306	11.3	AUG-08-73	1506	1.32	ANESTHESIA ACCIDENT, ADRENOCORTICAL HYPOPLASIA
T111M30	506	9.81	0.303	11.2	AUG-08-73	4774	1.06	SPECIAL STUDY
T112M30	506	6.92	0.333	12.3	OCT-23-73	44	0.14	INTUSSUSCEPTION
T113M30	499	9.35	0.333	12.3	OCT-23-73	3760	2.00	HEMANGIOSARCOMA (SOFT TISSUE)
T114M30	531	12.9	0.300	11.1	JUL-02-74	1505	5.18	OSTEOSARCOMA
T142M30	586	9.76	0.299	11.1	JAN-28-76	2504	1.96	OSTEOSARCOMA
T143M30	533	9.21	0.317	11.7	FEB-04-76	2421	6.62	OSTEOSARCOMA
T146M30	593	7.07	0.301	11.1	FEB-13-76	3098	1.00	ENTERITIS
T154M30	535	9.96	0.287	10.6	AUG-04-76	21	0.08	SPECIAL STUDY
T155M30	532	10.2	0.280	10.4	AUG-04-76	2380	1.97	ENCEPHALOPATHY
T156M30	528	10.0	0.286	10.6	AUG-04-76	3654	2.46	SPECIAL STUDY
T157M30	526	9.99	0.286	10.6	AUG-04-76	23	0.07	SPECIAL STUDY
T175M30+	3662	13.0	0.238	8.81	SEP-20-83	1554	4.04	UNDETERMINED
T176M30+	3726	9.35	0.330	12.2	SEP-20-83	415	0.72	MAMMARY ADENOCARCINOMA
T177M30	687	14.3	0.216	7.99	SEP-20-83	2240	1.26	SPECIAL STUDY
T178M30	687	10.5	0.294	10.9	SEP-20-83	2240	1.72	SPECIAL STUDY
T181M30	2267	9.60	0.310	11.5	MAR-26-86	9	0.03	SPECIAL STUDY
T182M30	1775	10.6	0.280	10.4	APR-04-86	10	0.03	SPECIAL STUDY
T183M30	3512	8.90	0.340	12.6	APR-21-86	9	0.03	SPECIAL STUDY
T184M30	2269	11.0	0.270	9.99	APR-22-86	10	0.03	SPECIAL STUDY
T185M30	1179	8.60	0.350	13.0	MAY-07-86	9	0.03	SPECIAL STUDY
T186M30	1116	9.80	0.310	11.5	MAY-12-86	9	0.03	SPECIAL STUDY
T117M40	385	9.98	1.20	44.4	NOV-19-74	1416	16.6	OSTEOSARCOMA
T118M40	385	8.96	1.34	49.6	NOV-19-74	3330	2.17	UNDETERMINED (NO SKELETAL TUMOR)
T119M40	385	8.36	1.44	53.3	NOV-19-74	3252	1.30	PNEUMONIA
T144M40	397	11.8	0.804	29.7	MAY-19-76	545	5.20	SPECIAL STUDY

B.11 ^{241}Am, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T145W40	397	11.6	0.983	36.4	MAY-19-76	545	6.34	SPECIAL STUDY
T168W40	997	9.80	0.976	36.1	JUN-21-78	7	0.07	SPECIAL STUDY
T169W40	934	10.4	0.919	34.0	JUN-21-78	7	0.06	SPECIAL STUDY
T170W40	986	10.2	0.937	34.7	JUN-21-78	7	0.05	SPECIAL STUDY
T171W40	856	9.00	1.06	39.2	JUN-21-78	7	0.04	SPECIAL STUDY
T172W40	876	11.6	0.824	30.5	JUN-21-78	7	0.04	SPECIAL STUDY
T173W40	933	11.7	0.817	30.2	JUN-20-78	8	0.07	SPECIAL STUDY
T174W40	994	8.50	1.12	41.4	JUN-18-78	10	0.11	SPECIAL STUDY
T179W40Y	87	3.45	0.896	33.2	OCT-11-83	2220	2.64	SPECIAL STUDY
T180W40Y	87	3.65	0.846	31.3	OCT-11-83	2220	2.49	SPECIAL STUDY
T016W50	461	10.7	2.78	103.	JAN-29-68	22	0.54	SPECIAL STUDY
T056W50	552	11.3	2.90	107.	NOV-25-69	15	0.48	SPECIAL STUDY
T057W50	496	7.01	2.77	102.	JAN-26-70	15	0.41	SPECIAL STUDY
T099W50	547	11.3	2.67	98.8	NOV-10-70	252	7.13	SPECIAL STUDY
T101W50	399	10.4	2.98	110.	AUG-17-72	1	0.03	SPECIAL STUDY
T107W50	3542	9.24	2.34	86.6	APR-02-73	36	0.81	MELANOMA (MOUTH)
T120W50	2894	8.77	3.17	117.	FEB-24-75	283	10.2	DEGENERATION (LIVER AND KIDNEY)
T147W50N	1	0.25	3.11	115.	FEB-01-76	1	0.06	SPECIAL STUDY
T148W50N	1	0.26	2.97	110.	FEB-01-76	3	0.21	SPECIAL STUDY
T149W50N	1	0.27	2.88	107.	FEB-01-76	5	0.33	SPECIAL STUDY
T150W50N	1	0.28	2.79	103.	FEB-01-76	5	0.32	SPECIAL STUDY
T151W50N	1	0.24	3.20	118.	FEB-01-76	1	0.06	SPECIAL STUDY
T152W50N	1	0.25	3.11	115.	FEB-01-76	1	0.07	SPECIAL STUDY
T153W50N	1	0.27	2.84	105.	FEB-01-76	3	0.18	SPECIAL STUDY
T015W55	858	11.5	4.53	168.	OCT-23-67	1	0.04	SPECIAL STUDY
T032W55	553	11.0	4.46	165.	APR-30-68	7	0.27	SPECIAL STUDY
T033W55	393	10.5	4.47	165.	APR-30-68	8	0.33	SPECIAL STUDY

B.12 ^{210}Bi, Test Studies

DOG NUMBER	INJECTION: AGE (DAYS)	INJECTION: WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	INJECTION: DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001D30	695	10.9	8.00	296	AUG-06-80	1	0.01	SPECIAL STUDY
T002D30	676	10.4	7.95	294	AUG-07-80	2/24	0.01	SPECIAL STUDY
T003D30	603	9.02	7.70	285	AUG-19-80	1	0.01	SPECIAL STUDY
T004D30	681	9.95	8.40	311	AUG-27-80	2/24	0.01	SPECIAL STUDY
T005D30	1338	10.8	11.0	407	JAN-06-82	1	0.01	SPECIAL STUDY
T006D30	1264	11.2	7.08	262	JAN-13-82	2/24	0.01	SPECIAL STUDY

B.13 ^{249}Cf, Test Studies

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001G50	597	12.2	2.84	105	FEB-24-71	500	20.2	NEPHRITIS,MYOCARDIAL INFARCTION
T002G50	584	10.7	2.77	102	FEB-24-71	7	0.29	SPECIAL STUDY
T003G50	584	9.89	2.80	104	FEB-24-71	21	0.82	SPECIAL STUDY

B.14 ^{252}Cf, Test Studies

DOG NUMBER	INJECTION					POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
	AGE (DAYS)	WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED			
T001F50	586	11.4	2.81	104	SEP-08-71	36	2.87	SPECIAL STUDY
T002F50	540	10.7	2.87	106	NOV-17-71	13	1.04	SPECIAL STUDY

B.15 $^{243,244}Cm$, Test Studies

DOG NUMBER	INJECTION: AGE (DAYS)	INJECTION: WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	INJECTION: DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T007C30	596	8.38	0.308	11.4	APR-29-80	7	0.03	SPECIAL STUDY
T008C30	596	8.43	0.306	11.3	APR-29-80	28	0.12	SPECIAL STUDY
T009C30	576	9.47	0.310	11.5	APR-29-80	111	0.42	SPECIAL STUDY
T001C50	511	10.4	2.60	96.2	FEB-27-73	1142	35.5	DEGENERATION (LIVER AND KIDNEY)
T002C50	485	12.2	2.64	97.7	FEB-27-73	6	0.21	SPECIAL STUDY
T003C50	485	11.4	2.64	97.7	FEB-27-73	13	0.46	SPECIAL STUDY
T004C50	485	12.5	2.64	97.7	FEB-27-73	20	0.71	SPECIAL STUDY
T005C50	485	12.8	2.63	97.3	FEB-27-73	384	13.0	DEGENERATION (LIVER)
T006C50	498	10.7	2.90	107.	OCT-22-73	87	2.88	SPECIAL STUDY

B.16 ^{253}Es, Test Studies

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001E50	470	9.82	2.87	106	JUN-05-73	7	0.20	SPECIAL STUDY
T002E50	483	12.2	2.89	107	JUN-05-73	21	0.77	SPECIAL STUDY
T003E50	483	11.0	2.84	105	JUN-05-73	55	1.38	SPECIAL STUDY
T004E50	484	12.3	2.97	110	JUN-06-73	2428	1.60	ABSCESS (LUNG), EMPYEMA
T005E50	484	11.2	2.93	108	SEP-10-73	7	0.34	SPECIAL STUDY

B.17 ^{210}Pb, Test Studies

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001D30	695	10.9	8.00	296	AUG-06-80	1	0.01	SPECIAL STUDY
T002D30	676	10.4	7.95	294	AUG-07-80	2/24	0.01	SPECIAL STUDY
T003D30	603	9.02	7.70	285	AUG-19-80	1	0.01	SPECIAL STUDY
T004D30	681	9.95	8.40	311	AUG-27-80	2/24	0.01	SPECIAL STUDY
T005D30	1338	10.8	11.0	407	JAN-06-82	1	0.01	SPECIAL STUDY
T006D30	1264	11.2	7.08	262	JAN-13-82	2/24	0.01	SPECIAL STUDY

B.18 ^{237}Pu or ^{241}Pu, Test Studies

DOG NUMBER	AGE (DAYS)	WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001K10	520	9.53	0.0286	1.06	DEC-10-74	13	0.01	SPECIAL STUDY
T002K10	517	10.3	0.0266	0.984	DEC-10-74	20	0.01	SPECIAL STUDY
T003K10	517	9.72	0.0281	1.04	DEC-10-74	27	0.01	SPECIAL STUDY
T021K17	515	9.80	504.	18648.	FEB-28-80	7	0.20	SPECIAL STUDY
T022K17Y	92	4.35	369.	13653.	APR-08-80	2	0.04	SPECIAL STUDY
T023K17Y	89	3.47	462.	17094.	APR-08-80	21	1.03	SPECIAL STUDY
T024K17	542	12.2	507.	18759.	JUL-30-81	6	0.17	SPECIAL STUDY

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T001K10 THROUGH T003K10 WERE INJECTED WITH PU-237.
T002K17 THROUGH T024K17 WERE INJECTED WITH PU-241.

B.19 ^{239}Pu, Test Studies

DOG NUMBER	AGE (DAYS)	WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T022P00								REASSIGNED, SEE F006T00A
T064P00								REASSIGNED, SEE T124P17
T090P00	487	7.60			MAY-06-75	378		SPECIAL STUDY
T105P00	574	11.8			FEB-23-76	11		SPECIAL STUDY
T108P00	581	10.3			FEB-06-76	14		SPECIAL STUDY
T109P00	581	8.50			FEB-13-76	4		SPECIAL STUDY
T110P00	579	9.31			FEB-12-76	7		SPECIAL STUDY
T114P00	555	9.25			FEB-26-76	18		SPECIAL STUDY
T115P00	570	13.2			MAR-12-76	4		SPECIAL STUDY
T180P00	502	9.78			FEB-24-77	27		SPECIAL STUDY
T182P00	518	8.52			MAR-24-77	56		SPECIAL STUDY
T183P00	516	11.3			APR-14-77	28		SPECIAL STUDY
T201P00	579	8.95			OCT-04-77	29		SPECIAL STUDY
T258P00E	557	55.5			AUG-03-82	1645		SPECIAL STUDY
T259P00E	557	58.5			AUG-03-82	1645		SPECIAL STUDY
T260P00E	557	60.3			AUG-03-82	1647		SPECIAL STUDY
T275P00+	1810	11.2			JAN-21-86	28		SPECIAL STUDY
T276P00+	1825	11.1			JAN-21-86	224		SPECIAL STUDY
T277P00+	1825	11.2			JAN-21-86	455		SPECIAL STUDY
T083P01E	575	51.3	0.00061	0.0226	AUG-22-73	2390	0.01	ARTHRITIS
T084P01E	517	55.7	0.00066	0.0244	FEB-19-75	3761	0.02	DIGESTIVE DISORDER
T085P01E	557	52.0	0.00071	0.0263	APR-01-75	2372	0.01	LYMPHOSARCOMA
T080P02E	569	48.7	0.00153	0.0566	JUL-25-73	3381	0.04	UNDETERMINED (NO TUMOR)
T081P02E	569	44.3	0.00157	0.0581	JUL-25-73	3709	0.04	OSTEOSARCOMA
T082P02E	597	47.2	0.00191	0.0707	AUG-22-73	3702	0.05	MAST CELL SARCOMA
T071P05E	588	48.9	0.00521	0.193	MAY-09-72	3011	0.12	THROMBOEMBOLISM
T072P05E	611	44.5	0.00512	0.189	JUN-01-72	2851	0.12	ACARIAN DERMATITIS
T073P05E	611	38.8	0.00507	0.188	JUN-01-72	3371	0.13	EMPYEMA, ISLET CELL TUMOR
T079P05	483	11.1	0.00523	0.194	JUN-05-73	134	0.01	SPECIAL STUDY
T252P05E	530	44.4	0.00494	0.183	NOV-17-81	2509		BATTELLE LABS
T253P05E	530	46.4	0.00494	0.183	NOV-17-81	2509	0.10	BATTELLE LABS - DEAD (NO CAUSE REC'D)
T254P05E	558	42.0	0.00490	0.181	DEC-15-81	2481	0.10	BATTELLE LABS - DEAD (NO CAUSE REC'D)
T023P10	1485	13.1	0.0172	0.636	JUL-28-61	96	0.02	SPECIAL STUDIES
T024P10	559	13.1	0.0172	0.636	JUL-28-61	97	0.02	SPECIAL STUDY
T025P10	559	13.8	0.0167	0.618	JUL-28-61	467	0.09	SPECIAL STUDY
T026P10	556	12.0	0.0160	0.592	JUL-28-61	647	0.11	SPECIAL STUDY
T028P10	552	10.5	0.0150	0.555	AUG-09-61	559	0.09	SPECIAL STUDY
T030P10	548	12.4	0.0148	0.548	AUG-09-61	35	0.01	SPECIAL STUDY
T032P10	519	8.47	0.0162	0.599	AUG-09-61	274	0.05	SPECIAL STUDY
T033P10	550	10.7	0.0153	0.566	SEP-15-61	375	0.07	SPECIAL STUDY
T034P10	550	9.68	0.0154	0.570	SEP-15-61	746	0.12	SPECIAL STUDY
T036P10	544	10.4	0.0158	0.585	SEP-15-61	5	0.01	SPECIAL STUDY
T037P10	542	8.59	0.0148	0.548	SEP-15-61	186	0.03	SPECIAL STUDY

B.19 ^{239}Pu, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T039P10	1534	10.7	0.0151	0.559	SEP-15-61	376	0.06	SPECIAL STUDY
T040P10	1534	9.92	0.0177	0.655	SEP-15-61	769	0.13	SPECIAL STUDY
T049P10	102	5.00	0.0162	0.599	JUL-05-66	5400	0.43	SENILITY
T068P10E	569	44.2	0.0158	0.585	APR-20-72	2393	0.31	OSTEOSARCOMA
T069P10E	569	32.0	0.0160	0.592	APR-20-72	3338	0.41	OSTEOSARCOMA
T070P10E	588	40.6	0.0152	0.562	MAY-09-72	3109	0.37	MANGE (DEMODECTIC), THROMBOEMBOLISM
T089P10	490	8.99	0.0176	0.651	MAY-06-75	379	0.08	SPECIAL STUDY
T091P10	488	10.6	0.0134	0.496	MAY-13-75	7	0.01	SPECIAL STUDY
T092P10	488	10.8	0.0134	0.496	MAY-13-75	29	0.01	SPECIAL STUDY
T093P10	488	9.04	0.0144	0.533	MAY-13-75	133	0.02	SPECIAL STUDY
T094P10	500	11.1	0.0166	0.614	MAY-28-75	27	0.01	SPECIAL STUDY
T095P10	511	9.46	0.0178	0.659	JUN-05-75	60	0.01	SPECIAL STUDY
T096P10	501	10.9	0.0159	0.588	JUL-08-75	7	0.01	SPECIAL STUDY
T097P10	490	13.0	0.0164	0.607	JUN-10-75	211	0.04	SPECIAL STUDY
T098P10	490	11.5	0.0162	0.599	JUN-10-75	209	0.04	SPECIAL STUDY
T099P10	497	10.9	0.0151	0.559	JUN-17-75	15	0.01	SPECIAL STUDY
T100P10	487	13.0	0.0155	0.574	JUN-24-75	363	0.07	SPECIAL STUDY
T101P10	490	10.0	0.0158	0.585	AUG-22-75	56	0.01	SPECIAL STUDY
T102P10	494	11.7	0.0152	0.562	AUG-26-75	140	0.03	SPECIAL STUDY
T103P10	490	8.97	0.0157	0.581	SEP-05-75	14	0.01	SPECIAL STUDY
T181P10	518	8.44	0.0162	0.599	MAR-24-77	33	0.01	SPECIAL STUDY
T184P10	516	9.60	0.0168	0.622	APR-14-77	56	0.01	SPECIAL STUDY
T202P10	587	7.67	0.0173	0.640	OCT-12-77	27	0.01	SPECIAL STUDY
T218P10W	611	10.2	0.0116	0.429	OCT-25-78	7	0.01	SPECIAL STUDY
T248P10E	539	56.6	0.0154	0.570	MAR-11-81	2760	0.34	DEAD (NO CAUSE REC'D) - BATTELLE LABS
T261P10+	1834	10.0	0.0162	0.599	NOV-19-85	182	0.04	SPECIAL STUDY
T262P10+	1836	8.77	0.0161	0.596	NOV-21-85	182	0.04	SPECIAL STUDY
T263P10+	1825	11.7	0.0160	0.592	JAN-21-86	112	0.02	SPECIAL STUDY
T264P10+	1837	8.81	0.0160	0.592	JAN-23-86	112	0.02	SPECIAL STUDY
T265P10+	1834	10.4	0.0159	0.588	FEB-18-86	14	0.01	SPECIAL STUDY
T266P10+	1836	14.5	0.0160	0.592	FEB-20-86	14	0.01	SPECIAL STUDY
T278P10	595	10.8	0.0213	0.788	JAN-21-86	77	0.02	SPECIAL STUDY
T279P10	597	14.4	0.0160	0.592	JAN-23-86	56	0.01	SPECIAL STUDY
T280P10	561	11.1	0.0160	0.592	FEB-25-86	14	0.01	SPECIAL STUDY
T281P10	563	10.2	0.0161	0.596	FEB-27-86	14	0.01	SPECIAL STUDY
T292P10	577	9.80	0.0164	0.607	MAR-13-86	448	0.08	SPECIAL STUDY
T104P17	565	7.75	0.0477	1.76	JAN-16-76	11	0.01	SPECIAL STUDY
T106P17	585	8.84	0.0455	1.68	FEB-06-76	3	0.01	SPECIAL STUDY
T107P17	581	9.35	0.0451	1.67	FEB-06-76	7	0.01	SPECIAL STUDY
T111P17	578	8.56	0.0433	1.60	FEB-11-76	14	0.01	SPECIAL STUDY
T112P17	589	8.90	0.0435	1.61	FEB-23-76	4	0.01	SPECIAL STUDY
T113P17	548	10.6	0.0438	1.62	FEB-19-76	18	0.01	SPECIAL STUDY
T124P17	2558	7.68	0.0527	1.95	MAY-13-76	118	0.07	SPECIAL STUDY

B.19 ^{239}Pu, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T226P17W	625	8.65	0.0319	1.18	JUN-06-79	7	0.01	SPECIAL STUDY
T227P17W	615	8.65	0.0319	1.18	JUN-06-79	7	0.01	SPECIAL STUDY
T228P17W	625	8.45	0.0327	1.21	JUN-06-79	7	0.01	SPECIAL STUDY
T229P17W	615	9.30	0.0297	1.10	JUN-06-79	7	0.01	SPECIAL STUDY
T230P17W	695	9.95	0.0277	1.02	JUN-06-79	7	0.01	SPECIAL STUDY
T231P17W	591	7.75	0.0356	1.32	JUN-06-79	7	0.01	SPECIAL STUDY
T244P17W	667	12.5	0.0153	0.566	JUL-29-80	7	0.01	SPECIAL STUDY
T245P17W	667	13.6	0.0140	0.518	JUL-29-80	7	0.01	SPECIAL STUDY
T057P20E	618	49.4	0.0961	3.56	SEP-10-69	1506	1.35	OSTEOSARCOMA
T061P20E	580	47.2	0.0983	3.64	JAN-06-70	1639	1.47	OSTEOSARCOMA
T062P20E	583	52.5	0.156	5.77	JAN-22-70	1223	1.86	OSTEOSARCOMA
T117P20Y	96	3.79	0.108	4.00	JAN-15-76	7	0.01	SPECIAL STUDY
T118P20Y	96	3.87	0.105	3.89	JAN-15-76	14	0.02	SPECIAL STUDY
T119P20Y	84	4.42	0.0922	3.41	JAN-15-76	28	0.06	SPECIAL STUDY
T120P20Y	96	4.85	0.0840	3.11	JAN-15-76	56	0.11	SPECIAL STUDY
T121P20Y	84	3.64	0.112	4.14	JAN-15-76	119	0.14	SPECIAL STUDY
T122P20Y	96	3.69	0.110	4.07	JAN-15-76	89	0.13	SPECIAL STUDY
T123P20	2416	10.5	0.0882	3.26	MAR-05-76	14	0.01	SPECIAL STUDY
T125P20N	2	0.32	0.127	4.70	JUN-22-76	3	0.01	SPECIAL STUDY
T126P20N	2	0.29	0.160	5.92	JUN-22-76	3	0.01	SPECIAL STUDY
T127P20N	2	0.31	0.148	5.48	JUL-19-76	1	0.01	SPECIAL STUDY
T128P20N	2	0.30	0.153	5.66	JUL-19-76	1	0.01	SPECIAL STUDY
T129P20N	2	0.28	0.197	7.29	JUL-19-76	1	0.01	SPECIAL STUDY
T154P20N	2	0.20	0.154	5.70	NOV-09-76	7	0.01	SPECIAL STUDY
T155P20N	2	0.20	0.151	5.59	NOV-09-76	7	0.01	SPECIAL STUDY
T156P20N	2	0.28	0.0897	3.32	NOV-09-76	7	0.01	SPECIAL STUDY
T158P20	695	9.68	0.0866	3.20	JAN-11-77	14	0.02	SPECIAL STUDY
T159P20	700	10.7	0.0783	2.90	JAN-11-77	14	0.01	SPECIAL STUDY
T160P20	689	8.71	0.0962	3.56	JAN-11-77	14	0.02	SPECIAL STUDY
T161P20	700	10.4	0.0806	2.98	JAN-11-77	14	0.01	SPECIAL STUDY
T162P20	686	9.59	0.0874	3.23	JAN-11-77	14	0.02	SPECIAL STUDY
T163P20	686	10.6	0.0791	2.93	JAN-11-77	14	0.01	SPECIAL STUDY
T164P20	686	10.0	0.0838	3.10	JAN-11-77	14	0.02	SPECIAL STUDY
T165P20	695	10.4	0.0806	2.98	JAN-11-77	14	0.01	SPECIAL STUDY
T166P20	707	9.27	0.0904	3.34	FEB-01-77	14	0.02	SPECIAL STUDY
T167P20	707	12.6	0.0665	2.46	FEB-01-77	14	0.01	SPECIAL STUDY
T168P20	707	9.39	0.0893	3.30	FEB-01-77	14	0.02	SPECIAL STUDY
T169P20	699	10.9	0.0769	2.85	FEB-01-77	14	0.01	SPECIAL STUDY
T170P20	699	10.8	0.0776	2.87	FEB-01-77	14	0.01	SPECIAL STUDY
T171P20	710	11.3	0.0742	2.75	FEB-01-77	14	0.01	SPECIAL STUDY
T172P20	699	9.79	0.0856	3.17	FEB-01-77	14	0.02	SPECIAL STUDY
T173P20	707	10.4	0.0806	2.98	FEB-01-77	14	0.01	SPECIAL STUDY
T174P20Y	93	3.52	0.0989	3.66	FEB-08-77	903	0.55	SPECIAL STUDY

B.19 ^{239}Pu, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T175P20Y	93	3.14	0.0936	3.46	FEB-08-77	512	0.34	SPECIAL STUDY
T176P20Y	93	2.89	0.0953	3.53	FEB-08-77	360	0.26	SPECIAL STUDY
T177P20Y	92	4.01	0.0981	3.63	FEB-08-77	364	0.27	SPECIAL STUDY
T178P20Y	92	4.34	0.0969	3.59	FEB-08-77	513	0.35	SPECIAL STUDY
T179P20Y	92	3.60	0.0967	3.58	FEB-08-77	669	0.43	SPECIAL STUDY
T185P20Y	90	3.31	0.0941	3.48	MAR-09-78	182	0.16	SPECIAL STUDY
T186P20Y	88	3.71	0.0918	3.40	MAY-09-78	86	0.09	SPECIAL STUDY
T187P20Y	93	3.20	0.0994	3.68	NOV-21-78	28	0.03	SPECIAL STUDY
T188P20Y	88	3.32	0.0988	3.66	NOV-21-78	128	0.13	SPECIAL STUDY
T203P20	580	10.9	0.0826	3.06	SEP-05-78	7	0.01	SPECIAL STUDY
T204P20	563	7.70	0.117	4.33	SEP-06-78	7	0.01	SPECIAL STUDY
T205P20	520	9.55	0.0943	3.49	SEP-07-78	7	0.01	SPECIAL STUDY
T206P20	1282	11.2	0.0804	2.97	AUG-24-78	7	0.01	SPECIAL STUDY
T207P20	942	9.20	0.0979	3.62	AUG-24-78	7	0.01	SPECIAL STUDY
T208P20	942	10.9	0.0827	3.06	AUG-24-78	7	0.01	SPECIAL STUDY
T209P20	940	9.80	0.0919	3.40	AUG-24-78	7	0.01	SPECIAL STUDY
T210P20	920	9.25	0.0974	3.60	AUG-24-78	7	0.01	SPECIAL STUDY
T211P20	1295	7.40	0.122	4.51	AUG-23-78	8	0.01	SPECIAL STUDY
T212P20	802	8.80	0.103	3.81	AUG-21-78	10	0.01	SPECIAL STUDY
T213P20W	553	9.50	0.0703	2.60	OCT-10-78	7	0.01	SPECIAL STUDY
T214P20W	553	9.00	0.0742	2.75	OCT-10-78	7	0.01	SPECIAL STUDY
T215P20W	553	8.60	0.0777	2.87	OCT-10-78	7	0.01	SPECIAL STUDY
T216P20W	537	11.4	0.0586	2.17	OCT-10-78	7	0.01	SPECIAL STUDY
T217P20W	537	9.40	0.0711	2.63	OCT-10-78	7	0.01	SPECIAL STUDY
T219P20W	904	12.0	0.0731	2.70	DEC-01-78	32	0.08	SPECIAL STUDY
T220P20W	904	11.3	0.0776	2.87	DEC-01-78	42	0.11	SPECIAL STUDY
T221P20W	806	9.36	0.0938	3.47	DEC-01-78	35	0.11	SPECIAL STUDY
T232P20W	568	10.4	0.102	3.77	SEP-13-79	7	0.01	SPECIAL STUDY
T233P20W	560	12.0	0.0882	3.26	SEP-13-79	7	0.01	SPECIAL STUDY
T234P20W	560	11.6	0.0913	3.38	SEP-13-79	7	0.01	SPECIAL STUDY
T235P20W	540	8.75	0.121	4.48	SEP-13-79	7	0.01	SPECIAL STUDY
T236P20W	566	11.2	0.0946	3.50	SEP-13-79	7	0.01	SPECIAL STUDY
T237P20W	560	10.3	0.103	3.81	SEP-13-79	7	0.01	SPECIAL STUDY
T238P20W	581	10.2	0.104	3.85	SEP-26-79	7	0.01	SPECIAL STUDY
T239P20W	541	10.8	0.0980	3.63	OCT-29-79	7	0.01	SPECIAL STUDY
T246P20Y	90	2.09	0.120	4.44	JAN-20-81	14	0.02	SPECIAL STUDY
T255P20E	830	54.0	0.0956	3.54	SEP-22-83	42	0.05	SPECIAL STUDY
T267P20+	1827	10.5	0.0957	3.54	APR-15-86	7	0.01	SPECIAL STUDY
T268P20+	1826	12.1	0.0956	3.54	APR-17-86	7	0.01	SPECIAL STUDY
T269P20+	1840	10.6	0.0948	3.51	MAY-27-86	224	0.23	SPECIAL STUDY
T270P20+	1846	11.7	0.0957	3.54	MAY-29-86	224	0.23	SPECIAL STUDY
T271P20+	1839	15.4	0.0956	3.54	JUN-10-86	28	0.03	SPECIAL STUDY
T272P20+	1841	14.1	0.0962	3.56	JUN-12-86	28	0.03	SPECIAL STUDY

B.19 ^{239}Pu, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T273P20+	1846	8.83	0.0943	3.49	JUN-10-86	56	0.06	SPECIAL STUDY
T274P20+	1848	10.1	0.0958	3.54	JUN-12-86	56	0.06	SPECIAL STUDY
T282P20	568	9.03	0.0961	3.56	MAR-18-86	224	0.26	SPECIAL STUDY
T283P20	570	11.7	0.0960	3.55	MAR-20-86	224	0.26	SPECIAL STUDY
T284P20	571	10.3	0.0959	3.55	MAR-25-86	455	0.50	SPECIAL STUDY
T285P20	573	11.2	0.0960	3.55	MAR-27-86	455	0.50	SPECIAL STUDY
T286P20	573	10.6	0.0967	3.58	MAR-25-86	112	0.14	SPECIAL STUDY
T287P20	575	10.3	0.0954	3.53	MAR-27-86	112	0.14	SPECIAL STUDY
T288P20	55		0.0972	3.60	APR-29-86	56	0.07	SPECIAL STUDY
T289P20	5		0.0964	3.57	MAY-01-86	56	0.07	SPECIAL STUDY
T290P20	56	0	0.0964	3.57	MAY-06-86	28	0.04	SPECIAL STUDY
T291P20	564	9.59	0.0965	3.57	MAY-08-86	28	0.03	SPECIAL STUDY
T293P20	566	11.1	0.0957	3.54	MAR-18-86	448	0.50	SPECIAL STUDY
T294P20	568	13.1	0.0957	3.54	MAR-20-86	448	0.50	SPECIAL STUDY
T295P20	556	13.8	0.0928	3.43	JUL-15-86	224	0.26	SPECIAL STUDY
T296P20	558	13.0	0.0924	3.42	JUL-17-86	224	0.25	SPECIAL STUDY
T297P20	563	11.0	0.0936	3.46	JUL-22-86	225	0.26	SPECIAL STUDY
T298P20	626	13.2	0.0901	3.33	SEP-23-86	56	0.07	SPECIAL STUDY
T299P20	554	12.4	0.0952	3.52	SEP-25-86	56	0.07	SPECIAL STUDY
T300P20	559	12.6	0.0952	3.52	SEP-30-86	56	0.07	SPECIAL STUDY
T301P20	608	12.6	0.0936	3.46	NOV-18-86	112	0.13	SPECIAL STUDY
T302P20	610	12.4	0.0952	3.52	NOV-20-86	112	0.14	SPECIAL STUDY
T303P20	560	12.8	0.0923	3.42	NOV-25-86	112	0.13	SPECIAL STUDY
T304P20	597	12.0	0.104	3.84	FEB-19-87	28	0.04	SPECIAL STUDY
T305P20	569	12.8	0.0959	3.55	FEB-24-87	28	0.04	SPECIAL STUDY
T306P20	571	10.7	0.0963	3.56	FEB-26-87	28	0.04	SPECIAL STUDY
T307P20	546	12.5	0.0878	3.25	MAY-05-87	7	0.01	SPECIAL STUDY
T308P20	548	13.1	0.0962	3.56	MAY-07-87	7	0.01	SPECIAL STUDY
T309P20+	1808	13.0	0.0947	3.50	MAY-13-86	448	0.44	SPECIAL STUDY
T310P20+	1816	13.1	0.0956	3.54	MAY-15-86	448	0.44	SPECIAL STUDY
T313P20Y	300	11.6	0.0890	3.29	APR-08-87	14	0.02	SPECIAL STUDY
T314P20Y	301	10.4	0.0890	3.29	APR-09-87	14	0.02	SPECIAL STUDY
T315P20Y	208	9.40	0.0942	3.49	AUG-13-87	14	0.02	SPECIAL STUDY
T316P20Y	209	10.9	0.0922	3.41	AUG-14-87	14	0.02	SPECIAL STUDY
T317P20Y	152	6.55	0.0991	3.67	MAY-14-87	14	0.02	SPECIAL STUDY
T318P20Y	150	7.18	0.104	3.85	JUN-16-87	14	0.02	SPECIAL STUDY
T319P20	580	13.5	0.0839	3.10	JUN-08-87	21	0.02	SPECIAL STUDY
T320P20	580	10.8	0.106	3.92	JUN-08-87	21	0.03	SPECIAL STUDY
T321P20	660	13.0	0.0970	3.59	SEP-29-87	14	0.02	SPECIAL STUDY
T322P20	661	12.1	0.0970	3.59	SEP-30-87	14	0.02	SPECIAL STUDY
T323P20	660	13.3	0.0980	3.63	SEP-29-87	63	0.08	SPECIAL STUDY
T324P20	661	13.4	0.0966	3.57	SEP-30-87	63	0.08	SPECIAL STUDY
T325P20	959	10.7	0.112	4.14	DEC-29-87	1	0.01	SPECIAL STUDY

B.19 ^{239}Pu, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T027P30	556	11.5	0.332	12.3	JUL-28-61	755	3.02	SPECIAL STUDY
T029P30	552	12.1	0.296	11.0	AUG-09-61	560	1.99	SPECIAL STUDY
T031P30	520	13.0	0.305	11.3	AUG-09-61	40	0.16	SPECIAL STUDY
T035P30	550	11.9	0.303	11.2	SEP-15-61	362	1.35	SPECIAL STUDY
T038P30	489	7.96	0.304	11.2	SEP-15-61	187	0.72	SPECIAL STUDY
T050P30	102	5.30	0.296	11.0	JUL-05-66	2835	8.63	OSTEOSARCOMA
T058P30E	573	52.3	0.291	10.8	SEP-10-69	917	3.12	OSTEOSARCOMA
T059P30E	591	44.5	0.290	10.7	NOV-05-69	973	3.28	OSTEOSARCOMA
T060P30E	567	45.2	0.314	11.6	JAN-06-70	784	2.92	OSTEOSARCOMA
T077P30	3413	9.95	0.310	11.5	MAR-28-73	1623	5.03	OSTEOSARCOMA
T078P30	2488	8.21	0.320	11.8	MAR-28-73	1633	5.22	OSTEOSARCOMA
T240P30+	2231	8.06	0.282	10.4	JUL-29-80	511	1.48	SPECIAL STUDY
T241P30+	2161	14.2	0.160	5.92	JUL-29-80	518	0.85	SPECIAL STUDY
T242P30+	2208	9.85	0.231	8.55	JUL-29-80	625	1.46	SPECIAL STUDY, PANCREATITIS
T243P30+	2001	9.10	0.250	9.25	JUL-29-80	657	1.65	SPECIAL STUDY, PANCREATITIS
T247P30+	1877	9.85	0.323	12.0	MAR-03-81	280	0.96	SPECIAL STUDY
T251P30+	1839	10.1	0.304	11.2	SEP-29-81	273	0.88	SPECIAL STUDY, PANCREATITIS
T256P30W	555	13.1	0.256	9.47	JAN-31-84	1753	1.69	OSTEOSARCOMA
T257P30W	555	9.98	0.336	12.4	JAN-31-84	2088	2.83	OSTEOSARCOMA
T311P30	950	14.2	0.300	11.1	NOV-25-86	7	0.03	SPECIAL STUDY
T312P30	950	12.7	0.299	11.1	NOV-25-86	49	0.19	SPECIAL STUDY
T052P40	437	11.8	0.949	35.1	JUL-07-67	14	0.17	SPECIAL STUDY
T055P40	445	10.6	0.785	29.0	JUN-03-69	14	0.14	SPECIAL STUDY
T065P40P	542	11.5	0.904	33.4	NOV-30-71	14	0.02	SPECIAL STUDY
T066P40P	542	10.6	0.913	33.8	NOV-30-71	1184	6.63	FIBROSARCOMA (SKELETON)
T067P40P	539	10.4	0.907	33.6	NOV-30-71	1148	6.30	OSTEOSARCOMA
T074P40	3694	7.73	0.937	34.7	MAR-28-73	705	7.41	UNDIFFERENTIATED MALIGNANCY (SOFT TISSUE)
T075P40	3478	8.47	0.897	33.2	MAR-28-73	1451	13.6	OSTEOSARCOMA
T076P40	3413	10.7	0.894	33.1	MAR-28-73	1357	12.8	OSTEOSARCOMA
T086P40E	525	46.0	0.903	33.4	FEB-27-75	901	9.87	OSTEOSARCOMA
T130P40P	609	9.66	0.788	29.2	NOV-18-76	60	0.10	SPECIAL STUDY
T131P40P	609	12.6	0.799	29.6	NOV-18-76	1097	1.10	THROMBOEMBOLISM
T132P40P	609	10.1	0.804	29.7	NOV-18-76	132	0.15	SPECIAL STUDY
T133P40P	609	9.95	0.800	29.6	NOV-18-76	1783	2.23	OSTEOSARCOMA
T134P40P	609	9.87	0.789	29.2	NOV-18-76	1660	2.91	ADAMANTINOMA, MALIGNANT
T135P40P	609	11.3	0.799	29.6	NOV-18-76	69	0.12	SPECIAL STUDY
T136P40P	603	10.2	0.794	29.4	NOV-18-76	3508	2.69	SPECIAL STUDY
T137P40P	609	11.4	0.792	29.3	NOV-18-76	257	0.69	SPECIAL STUDY
T138P40P	603	9.66	0.788	29.2	NOV-18-76	138	2.08	SPECIAL STUDY
T139P40P	609	12.2	0.798	29.5	NOV-18-76	417	1.32	SPECIAL STUDY
T140P40P	603	9.79	0.796	29.5	NOV-18-76	824	3.98	SPECIAL STUDY
T141P40P	602	10.3	0.790	29.2	NOV-18-76	40	0.05	SPECIAL STUDY
T142P40P	602	8.28	0.791	29.3	NOV-18-76	33	0.04	SPECIAL STUDY

B.19 ^{239}Pu, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T143P40P	603	10.2	0.798	29.5	NOV-18-76	1267	6.11	OSTEOSARCOMA
T144P40P	602	9.82	0.793	29.3	NOV-18-76	1288	5.87	OSTEOSARCOMA
T145P40P	603	10.0	0.791	29.3	NOV-18-76	117	0.21	SPECIAL STUDY
T146P40P	602	9.63	0.790	29.2	NOV-18-76	124	0.24	SPECIAL STUDY
T147P40P	597	11.0	0.804	29.7	NOV-18-76	1462	2.28	OSTEOSARCOMA
T148P40P	602	9.67	0.806	29.8	NOV-18-76	250	0.64	SPECIAL STUDY
T149P40P	597	9.86	0.790	29.2	NOV-18-76	3533	2.04	SPECIAL STUDY
T150P40P	597	9.84	0.792	29.3	NOV-18-76	424	1.34	SPECIAL STUDY
T151P40P	597	11.4	0.792	29.3	NOV-18-76	831	3.60	SPECIAL STUDY
T152P40P	597	8.90	0.796	29.5	NOV-18-76	1568	9.19	OSTEOSARCOMA
T157P40P	609	11.2	0.790	29.2	NOV-18-76	1594	7.08	OSTEOSARCOMA
T249P40	1413	8.38	0.924	34.2	MAY-13-81	8	0.08	SPECIAL STUDY
T250P40	1019	10.2	0.926	34.3	MAY-13-81	35	0.36	SPECIAL STUDY
T000P50	646	11.4	3.05	113.	JUN-24-52	1	0.04	SPECIAL STUDY
T001P50	1581	12.7	3.04	112.	OCT-13-52	29	1.06	SPECIAL STUDY
T002P50	914	11.9	6.85	253.	SEP-15-52	44	3.94	SPECIAL STUDY
T003P50	942	9.65	3.22	119.	OCT-13-52	610	24.8	SPECIAL STUDY
T004P50	1015	8.78	3.02	112.	OCT-13-52	365	11.6	SPECIAL STUDY
T005P50	474	10.4	2.69	99.5	DEC-14-54	400	13.7	SPECIAL STUDY
T006P50	527	6.16	2.73	101.	DEC-14-54	406	14.1	SPECIAL STUDY
T007P50	475	7.40	2.68	99.2	DEC-14-54	777	26.1	SPECIAL STUDY
T008P50	527	8.32	2.67	98.8	DEC-14-54	863	28.70	SPECIAL STUDY
T009P50	551	10.3	2.80	104.	NOV-22-55	15	0.55	SPECIAL STUDY
T010P50	534	11.9	2.74	101.	NOV-23-55	15	0.54	SPECIAL STUDY
T011P50	516	12.1	2.76	102.	NOV-22-55	28	1.01	SPECIAL STUDY
T012P50	487	9.23	2.74	101.	NOV-23-55	28	1.00	SPECIAL STUDY
T013P50	587	8.27	3.16	117.	APR-24-56	3	0.12	SPECIAL STUDY
T014P50	587	9.38	2.43	89.9	APR-24-56	7	0.22	SPECIAL STUDY
T015P50	737	8.32	2.79	103.	OCT-15-56	1	0.04	SPECIAL STUDY
T016P50	673	10.7	2.85	105.	OCT-10-56	92	3.41	SPECIAL STUDY
T017P50	739	11.1	3.01	111.	FEB-12-57	210	8.16	SPECIAL STUDY
T018P50	739	8.16	2.83	105.	FEB-12-57	217	7.93	SPECIAL STUDY
T019P50	688	8.86	2.91	108.	DEC-15-60	1400	49.8	OSTEOSARCOMA, BLOOD DYSCRASIA, DEGENERATION (LIVER)
T020P50	688	13.0	2.68	99.2	DEC-15-60	474	16.1	DEGENERATION (LIVER), ASCITES, THROMBOCYTOPENIA
T021P50	688	10.3	2.72	101.	DEC-15-60	939	31.7	NEPHRITIS, DEGENERATION (LIVER)
T041P50	543	8.50	3.01	111.	NOV-30-64	1227	45.4	PURPURA HEMORRHAGICA, DEGENERATION (LIVER)
T042P50	510	11.4	2.40	88.8	FEB-10-65	13	0.41	SPECIAL STUDY
T043P50H	600	14.0	2.86	106.	JUL-15-65	40	1.52	SPECIAL STUDY
T044P50H	516	12.0	2.72	101.	SEP-21-65	35	1.25	SPECIAL STUDY
T046P50	420	11.9	3.01	111.	OCT-28-65	732	27.6	DEGENERATION (LIVER)
T047P50	803	12.4	3.02	112.	NOV-30-65	69	2.72	SPECIAL STUDY
T048P50	554	8.50	2.61	96.6	MAR-11-66	1327	42.4	UNDIFFERENTIATED SARCOMA (SKELETON)
T051P50	103	4.80	2.73	101.	JUL-06-66	1055	20.8	OSTEOSARCOMA

B.19 ^{239}Pu, Test Studies (continued)

DOG NUMBER	AGE (DAYS)	WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T053P50	1517	13.9	2.82	104.	MAR-11-69	1559	39.2	DEGENERATION (LIVER)
T054P50	906	11.3	2.77	102.	MAR-11-69	404	14.3	SPECIAL STUDY
T063P50	581	9.13	2.77	102.	DEC-14-70	490	17.2	SPECIAL STUDY
T087P50	3008	10.1	2.93	108.	FEB-24-75	182	5.74	SPECIAL STUDY
T088P50	2194	9.80	3.01	111.	FEB-24-75	184	5.96	SPECIAL STUDY
T153P50	567	12.0	2.55	94.3	NOV-16-76	22	0.73	SPECIAL STUDY
T222P50Y	91	3.08	3.27	121.	JAN-15-79	7	0.33	SPECIAL STUDY
T223P50Y	91	2.18	2.77	102.	JAN-15-79	7	0.28	SPECIAL STUDY
T224P50Y	91	2.55	3.23	120.	JAN-15-79	14	0.65	SPECIAL STUDY
T225P50Y	91	2.08	2.72	101.	JAN-15-79	14	0.54	SPECIAL STUDY
T056P55	501	11.2	3.73	138.	JUL-29-69	7	0.34	SPECIAL STUDY
T116P55	533	8.72	4.32	160.	JAN-13-76	2	0.11	SPECIAL STUDY
T198P55	1560	7.92	4.57	169.	APR-10-78	2	0.10	SPECIAL STUDY
T199P55	1377	10.7	4.54	168.	APR-10-78	2	0.10	SPECIAL STUDY
T200P55	657	10.9	4.34	161.	JUN-13-77	2	0.11	SPECIAL STUDY

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FOR THE CALCULATION OF RADIATION DOSE FOR DOGS THAT HAD RECEIVED PARTICULATE PLUTONIUM, MEASURED SKELETAL WEIGHTS WERE USED. THE FOLLOWING SKELETAL PU-RETENTIONS (R) WERE APPLIED:

A. DOGS THAT RECEIVED NO FURTHER TREATMENT R = 60(1 - 0.914 exp0.00098t)exp-0.000237t.
B. DOGS THAT RECEIVED 30 MMOLES CaDTPA/KG ONCE WEEKLY R = 6.7% CONSTANT AVERAGE RETENTION.
C. DOGS THAT RECEIVED 309 UMOLES ZnDTPA/KG DAILY R = 2.8% CONSTANT AVERAGE RETENTION.

T117P20Y ... T122P20Y AND T123P20 WERE GIVEN TRACER PU-237 IN THE SAME SOLUTION CONTAINING THEIR PU-239.

DOGS IN THE SEQUENCE T213P20W ... T221P17W AND T226P17W ... T239P20W WERE GIVEN A MIXTURE OF PU-239, PU-237 AND AM-241.

T043P50H WAS ALSO GIVEN 37.4 KBQ/KG (1.01 UCI/KG) PU-239 ONE DAY PRIOR TO SACRIFICE.

T044P50H WAS GIVEN 30.8 KBQ/KG (0.833 UCI/KG) PU-239 AND 339 KBQ/KG (9.17 UCI/KG) FE-59 ONE DAY PRIOR TO SACRIFICE.

B.20 ^{224}Ra (Quickradium) Test Studies

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T019Q10	514	11.8	0.0475	1.76	FEB-01-68	4675	0.81	INANITION, DEGENERATION (KIDNEY)
T020Q10	514	10.4	0.0472	1.75	FEB-01-68	4717	0.81	ADENOMA (CHROMOPHOBE)
T021Q10	502	9.08	0.0447	1.65	FEB-01-68	4211	0.70	THROMBOEMBOLISM
T016Q20	514	9.36	0.310	11.5	FEB-01-68	3757	4.74	OSTEOSARCOMA
T017Q20	514	10.2	0.311	11.5	FEB-01-68	4893	5.46	OSTEOSARCOMA, THROMBOEMBOLISM
T018Q20	502	9.68	0.306	11.3	FEB-01-68	4961	5.40	SALIVARY GLAND TUMOR
T001Q30J	460	9.55	0.875	32.4	MAR-26-63	4/24	0.01	SPECIAL STUDY
T011Q30	495	9.10	0.885	32.7	DEC-04-63	3668	0.32	AORTIC BODY TUMOR
T012Q30	495	13.5	0.889	32.9	DEC-04-63	4087	0.32	THROMBOEMBOLISM
T013Q30	495	11.3	0.912	33.7	DEC-04-63	4605	0.33	CIRCULATORY FAILURE
T014Q30	438	10.3	0.870	32.2	DEC-04-63	4785	0.31	NEPHRITIS
T002Q40	466	12.0	2.91	108.	MAR-27-63	2317	6.71	OSTEOSARCOMA
T003Q40	466	13.1	2.91	108.	MAR-27-63	2708	7.31	HEMANGIOSARCOMA (SKELETON)
T009Q40	503	9.80	2.57	95.1	DEC-04-63	1451	0.88	STRANGULATION OF VOMITUS, STATUS EPILEPTICUS
T010Q40	503	10.3	2.57	95.1	DEC-04-63	262	0.80	STATUS EPILEPTICUS
T015Q40	514	12.7	2.73	101.	FEB-01-68	1692	25.8	OSTEOSARCOMA
T004Q50	479	9.55	9.71	359.	APR-24-63	1462	36.0	OSTEOSARCOMA, EPIDERMOID CARCINOMA (FRONTAL SINUS)
T005Q50	454	9.67	9.59	355.	APR-24-63	1638	38.2	OSTEOSARCOMA
T007Q50	465	11.8	8.56	317.	NOV-06-63	2053	3.61	OSTEOSARCOMA
T008Q50	475	9.77	8.62	319.	NOV-06-63	16	2.51	PURPURA HEMORRHAGICA
T022Q50	643	8.39	10.1	374.	DEC-13-77	3/24	0.04	SPECIAL STUDY
T023Q50	619	10.9	8.37	310.	JAN-03-78	1/24	0.01	SPECIAL STUDY
T024Q50	649	9.14	10.1	374.	DEC-19-77	1	0.49	SPECIAL STUDY
T025Q50	638	8.78	10.1	374.	JAN-10-78	8/24	0.14	SPECIAL STUDY
T026Q50	685	8.81	9.98	369.	JAN-24-78	7	2.29	SPECIAL STUDY
T027Q50	642	10.6	10.1	374.	JAN-14-78	3	1.37	SPECIAL STUDY
T028Q50	577	10.9	8.43	312.	DEC-04-79	1	0.41	SPECIAL STUDY
T029Q50	593	13.0	7.33	271.	APR-21-81	1	0.36	SPECIAL STUDY
T030Q50	606	12.2	9.75	361.	MAY-12-81	1	0.48	SPECIAL STUDY
T031Q50	775	10.5	10.6	392.	DEC-15-82	1	0.52	SPECIAL STUDY, PANCREATITIS
T006Q60	455	8.29	21.4	792.	OCT-17-63	13	6.47	PURPURA HEMORRHAGICA

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T001Q30J ALSO RECEIVED 666 KBQ (18.0 UCI) SR-85.

SKELETAL DOSES FOR T022Q50 TO T031Q50 ARE FROM RA-224 (AND DAUGHTERS). CONTAMINATION OF THE INJECTION SOLUTION WITH OTHER EMITTERS WAS NEGLIGIBLE. DOSIMETRIC DETAILS ARE TO BE FOUND IN COO-199-253, PP. 263-276, MARCH 1978.

FOR THE OTHER RA-224 TEST DOGS, THE SKELETAL DOSES ARE FROM RA-224 (AND DAUGHTERS) PLUS CONTAMINATION FROM PB-210 AND TH-228. IN SOME CASES THE PB-210 AND TH-228 CONTAMINATION WAS APPRECIABLE. PLEASE SEE THE ARTICLE, "RA-224 TOXICITY FROM A PILOT STUDY IN BEAGLES" IN COO-119-252, MARCH 1977, PP. 272-287, PARTICULARLY SEE P. 278. (NOTE THAT THE SKELETAL DOSES LISTED ON PAGE 278 OF THE REFERENCE CITED WERE CALCULATED FOR BEAGLES WITH 75 G SKELETON/KG BODY WEIGHT RATHER THAN 100 G/KG BODY WEIGHT AS USED HEREIN).

B.21 ^{226}Ra, Test Studies

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T039R00								REASSIGNED, SEE M012N00
T075R00	488	9.38			MAY-13-75	134		SPECIAL STUDY
T078R00	503	9.77			MAY-28-75	55		SPECIAL STUDY
T080R00	500	12.1			MAY-28-75	208		SPECIAL STUDY
T083R00	495	8.06			MAY-28-75	26		SPECIAL STUDY
T087R00	488	12.2			JUN-25-75	15		SPECIAL STUDY
T090R00	502	9.63			JUL-09-75	7		SPECIAL STUDY
T123R00E	540				JAN-07-74	3174		BLOAT
T124R00E	539				JUL-10-79	2772		SPECIAL STUDY
T155R00E	557	66.5			AUG-03-82	1010		LYMPHOSARCOMA
T156R00E	557	58.0			AUG-03-82	1025		HYDROCEPHALUS, CNS SYNDROME
T157R00E	557				DEC-23-82	1505		SPECIAL STUDY
T104R05E	519	47.9	0.0191	0.707	DEC-27-77	3314	0.85	SPECIAL STUDY, ADENOCARCINOMA, LUNG
T118R05E	565	46.9	0.0198	0.733	AUG-19-80	197	0.11	UNDIFFERENTIATED CARCINOMA (NOSE)
T119R05E	565	51.8	0.0196	0.725	AUG-19-80	3262	0.74	DEAD (NO CAUSE REC'D)
T133R05E	544	44.2	0.0192	0.710	DEC-01-81	2495		BATTELLE LABS
T134R05E	544	51.0	0.0191	0.707	DEC-01-81	2495		BATTELLE LABS
T040R10	899	13.0	0.0483	1.79	APR-03-62	7	0.01	SPECIAL STUDY
T041R10	899	12.7	0.0487	1.80	APR-03-62	63	0.04	SPECIAL STUDY
T105R10E	519	49.5	0.0558	2.06	DEC-27-77	1686	1.72	NEPHRITIS, PNEUMONIA, TOXEMIA, HEPATIC NECROSIS
T116R10E	524	41.1	0.0605	2.24	JUL-29-80	2575	1.68	SPECIAL STUDY
T117R10E	544	40.3	0.0617	2.28	JUL-29-80	1416	1.23	ARTHRITIS
T120R10E	527	49.8	0.0618	2.29	SEP-16-80	2770	2.15	DEAD (NO CAUSE REC'D)
T121R10E	527	49.0	0.0614	2.27	SEP-16-80	3411	2.30	DEAD (NO CAUSE REC'D)
T042R17	967	14.0	0.146	5.40	APR-04-62	7	0.02	SPECIAL STUDY
T043R17	963	13.2	0.145	5.37	APR-04-62	64	0.13	SPECIAL STUDY
T073R20	487	8.68	0.350	13.0	MAY-06-75	380	1.92	SPECIAL STUDY
T074R20	488	12.0	0.314	11.6	MAY-13-75	28	0.17	SPECIAL STUDY
T076R20	488	11.6	0.318	11.8	MAY-13-75	56	0.34	SPECIAL STUDY
T077R20	489	12.3	0.313	11.6	MAY-14-75	7	0.04	SPECIAL STUDY
T079R20	503	9.23	0.357	13.2	MAY-28-75	127	1.15	SPECIAL STUDY
T081R20	495	11.1	0.365	13.5	MAY-28-75	205	2.16	SPECIAL STUDY
T082R20	495	10.3	0.359	13.3	MAY-28-75	28	0.19	SPECIAL STUDY
T084R20	512	11.0	0.314	11.6	JUN-06-75	132	1.02	SPECIAL STUDY
T085R20	490	9.24	0.265	9.81	JUN-10-75	210	1.49	SPECIAL STUDY
T086R20	487	13.8	0.313	11.6	JUN-24-75	15	0.09	SPECIAL STUDY
T088R20	490	11.7	0.328	12.1	JUL-01-75	365	1.75	SPECIAL STUDY
T089R20	491	12.2	0.329	12.2	JUL-02-75	15	0.09	SPECIAL STUDY
T091R20	513	10.3	0.253	9.36	JUN-10-75	56	0.40	SPECIAL STUDY
T092R20	459	11.6	0.327	12.1	AUG-05-75	7	0.05	SPECIAL STUDY
T099R20E	564	55.4	0.335	12.4	NOV-03-77	1602	6.76	OSTEOSARCOMA
T100R20E	491	48.6	0.341	12.6	NOV-22-77	1727	7.94	OSTEOSARCOMA

B.21 ^{226}Ra, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T102R20E	501	47.3	0.342	12.7	DEC-09-77	1587	9.73	OSTEOSARCOMA
T158R20Y	300	12.5	0.463	17.1	JUN-12-87	14	0.16	SPECIAL STUDY
T159R20Y	300	9.40	0.488	18.1	OCT-09-87	14	0.17	SPECIAL STUDY
T160R20Y	210	8.92	0.484	17.9	JUL-08-87	14	0.16	SPECIAL STUDY
T161R20Y	209	11.0	0.482	17.8	JUL-09-87	14	0.16	SPECIAL STUDY
T162R20Y	150	8.05	0.498	18.4	MAY-11-87	15	0.17	SPECIAL STUDY
T163R20Y	150	7.20	0.483	17.9	MAY-12-87	15	0.16	SPECIAL STUDY
T028R30H	371	11.7	1.11	41.1	NOV-24-58	387	3.67	SPECIAL STUDY
T032R30	471	11.4	1.13	41.8	MAR-03-59	2249	20.3	OSTEOSARCOMA
T033R30	471	10.6	1.15	42.6	MAR-03-59	1822	20.6	OSTEOSARCOMA, NEPHRITIS
T034R30	470	15.7	1.12	41.4	MAR-03-59	1737	17.4	OSTEOSARCOMA
T035R30J	670	9.44	0.951	35.2	MAY-05-59	8	0.14	SPECIAL STUDY
T044R30	938	11.1	0.937	34.7	APR-04-62	68	0.82	SPECIAL STUDY
T045R30	940	13.6	0.941	34.8	APR-06-62	7	0.12	SPECIAL STUDY
T046R30	810	12.5	0.928	34.3	APR-05-62	69	1.14	SPECIAL STUDY
T063R30	559	8.72	0.899	33.3	JAN-29-64	36	0.56	SPECIAL STUDY
T064R30	551	8.42	0.919	34.0	JAN-29-64	63	0.85	SPECIAL STUDY
T065R30	551	11.6	0.922	34.1	JAN-29-64	70	1.11	SPECIAL STUDY
T066R30	549	10.1	0.904	33.4	JAN-29-64	132	1.65	SPECIAL STUDY
T067R30	549	12.7	0.898	33.2	JAN-29-64	134	1.92	SPECIAL STUDY
T068R30	549	12.1	0.917	33.9	JAN-29-64	1667	12.1	OSTEOSARCOMA
T069R30	498	8.84	0.919	34.0	JAN-29-64	622	6.75	SPECIAL STUDY
T070R30	498	14.2	0.922	34.1	JAN-29-64	1996	23.2	OSTEOSARCOMA
T093R30	576	7.75	0.969	35.9	JAN-27-76	3	0.06	SPECIAL STUDY
T094R30	571	9.88	0.930	34.4	JAN-23-76	11	0.24	SPECIAL STUDY
T095R30	584	10.2	1.03	38.1	FEB-17-76	14	0.36	SPECIAL STUDY
T096R30	584	7.94	0.990	36.6	FEB-17-76	7	0.13	SPECIAL STUDY
T097R30	583	10.8	0.972	36.0	FEB-26-76	4	0.09	SPECIAL STUDY
T098R30	549	9.51	0.966	35.7	FEB-20-76	18	0.34	SPECIAL STUDY
T101R30E	491	45.6	1.05	38.8	NOV-22-77	523	11.9	STATUS EPILEPTICUS
T103R30E	501	45.4	1.10	40.7	DEC-09-77	955	20.7	OSTEOSARCOMA
T107R30Y	101	4.41	1.01	37.4	FEB-21-80	119	1.94	SPECIAL STUDY
T108R30Y	101	3.97	1.06	39.2	FEB-21-80	238	3.64	SPECIAL STUDY
T109R30Y	101	3.73	1.05	38.8	FEB-21-80	364	5.88	SPECIAL STUDY
T110R30E	1297	58.8	1.04	38.5	FEB-13-80	15	0.37	SPECIAL STUDY
T111R30Y	92	4.67	1.06	39.2	MAR-13-80	21	0.51	SPECIAL STUDY
T112R30Y	92	3.52	1.05	38.8	MAR-13-80	49	1.08	SPECIAL STUDY
T113R30Y	92	3.17	1.09	40.3	APR-08-80	7	0.18	SPECIAL STUDY
T114R30Y	92	3.22	1.07	39.6	APR-08-80	14	0.34	SPECIAL STUDY
T135R30+	1850	10.8	1.14	42.2	AUG-01-84	7	0.11	SPECIAL STUDY
T136R30+	2276	11.2	1.14	42.2	AUG-01-84	14	0.25	SPECIAL STUDY
T137R30+	2194	11.8	1.14	42.2	AUG-22-84	34	0.57	SPECIAL STUDY

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T035R30J ALSO RECEIVED 3660 KBQ (99.0 UCI) SR-85.

B.21 ^{226}Ra, Test Studies (continued)

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T138R30+	1822	11.7	1.14	42.2	AUG-22-84	64	0.90	SPECIAL STUDY
T139R30+	2276	11.5	1.14	42.2	AUG-01-84	133	1.69	SPECIAL STUDY
T140R30+	1822	13.2	1.14	42.2	AUG-22-84	239	2.72	SPECIAL STUDY
T141R30+	2151	9.97	1.14	42.2	AUG-01-84	370	4.23	SPECIAL STUDY
T144R30	613	12.1	0.911	33.7	DEC-10-84	7	0.10	SPECIAL STUDY
T145R30	620	12.0	0.918	34.0	DEC-17-84	239	2.82	SPECIAL STUDY
T146R30	620	13.0	0.907	33.6	DEC-17-84	241	3.43	SPECIAL STUDY
T147R30	652	13.6	0.896	33.2	JAN-02-85	398	5.07	SPECIAL STUDY
T148R30	652	13.7	0.919	34.0	JAN-02-85	14	0.20	SPECIAL STUDY
T149R30	644	14.5	0.909	33.6	JAN-09-85	29	0.50	SPECIAL STUDY
T150R30	644	13.3	0.908	33.6	JAN-09-85	34	0.54	SPECIAL STUDY
T151R30	635	12.3	0.909	33.6	JAN-16-85	75	0.87	SPECIAL STUDY
T152R30	635	13.2	0.903	33.4	JAN-16-85	78	1.10	SPECIAL STUDY
T153R30	626	12.8	1.10	40.7	APR-02-85	118	1.79	SPECIAL STUDY
T154R30	609	10.2	1.10	40.7	APR-02-85	122	1.74	SPECIAL STUDY
T125R35N	2	0.32	1.53	56.6	JUL-06-81	2	0.02	SPECIAL STUDY
T126R35N	2	0.32	1.58	58.5	JUL-06-81	4	0.05	SPECIAL STUDY
T127R35N	2	0.30	1.66	61.4	JUL-06-81	4	0.05	SPECIAL STUDY
T128R35N	2	0.31	1.60	59.2	JUL-06-81	1	0.01	SPECIAL STUDY
T129R35N	2	0.31	1.60	59.2	JUL-06-81	14	0.17	SPECIAL STUDY
T130R35N	4	0.36	1.34	49.6	JUL-27-81	4	0.04	SPECIAL STUDY
T131R35N	4	0.40	1.20	44.4	JUL-27-81	7	0.07	SPECIAL STUDY
T132R35N	4	0.35	1.37	50.7	JUL-27-81	14	0.15	SPECIAL STUDY
T014R40	675	8.12	3.17	117.	JUL-12-56	72	3.90	SPECIAL STUDY
T015R40	672	9.03	3.11	115.	JUL-11-56	2127	53.9	OSTEOSARCOMA
T023R40N	384	9.50	4.05	150.	NOV-25-58	1471	54.1	OSTEOSARCOMA
T024R40N	383	11.9	3.24	120.	NOV-24-58	1505	44.1	OSTEOSARCOMA
T025R40N	378	11.3	3.42	127.	NOV-24-58	1309	41.6	OSTEOSARCOMA
T026R40N	378	11.0	3.48	129.	NOV-24-58	1780	54.0	OSTEOSARCOMA
T027R40N	371	11.5	3.34	124.	NOV-24-58	1414	43.3	OSTEOSARCOMA
T036R40	695	10.2	2.99	111.	DEC-22-60	1154	39.9	OSTEOSARCOMA
T037R40	695	9.53	3.00	111.	DEC-22-60	1627	36.8	OSTEOSARCOMA
T038R40	695	10.1	3.02	112.	DEC-22-60	1503	40.8	OSTEOSARCOMA
T057R40	500	12.1	2.72	101.	AUG-15-63	14	0.59	SPECIAL STUDY
T058R40	495	11.7	2.41	89.2	AUG-15-63	61	3.11	SPECIAL STUDY
T059R40	495	9.64	2.57	95.1	AUG-15-63	63	3.01	SPECIAL STUDY
T060R40	489	12.1	2.33	86.2	AUG-15-63	117	4.67	SPECIAL STUDY
T061R40	489	9.48	2.70	99.9	AUG-15-63	371	17.3	SPECIAL STUDY
T062R40	489	8.63	2.68	99.2	AUG-15-63	460	17.8	SPECIAL STUDY
T001R50	996	11.1	10.3	381.	DEC-01-52	1074	95.2	OSTEOSARCOMA
T002R50	919	8.40	4.39	162.	JAN-12-53	1368	47.6	OSTEOSARCOMA
T003R50	1467	8.29	4.76	176.	JAN-12-53	428	13.2	SPECIAL STUDY
T004R50	459	10.0	10.6	392.	JUL-06-53	1	0.14	SPECIAL STUDY

B.21 ^{226}Ra, Test Studies (continued)

DOG NUMBER	INJECTION: AGE (DAYS)	INJECTION: WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	INJECTION: DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T005R50	126	6.14	11.7	433.	OCT-06-53	1	0.15	SPECIAL STUDY
T006R50	126	6.14	11.4	422.	OCT-06-53	1	0.15	SPECIAL STUDY
T007R50	126	6.14	11.8	437.	OCT-06-53	1	0.15	SPECIAL STUDY
T008R50	320	5.52	1.92	71.	MAY-10-55	58	4.58	SPECIAL STUDY
T009R50	2274	10.4	1.94	71.8	MAY-10-55	58	5.48	SPECIAL STUDY
T010R50	44	1.02	1.98	73.3	MAY-11-55	49	2.79	SPECIAL STUDY
T011R50	44	1.58	1.91	70.7	MAY-11-55	49	3.44	SPECIAL STUDY
T012R50	397	12.3	9.72	360.	MAY-09-56	225	28.3	SPECIAL STUDY
T013R50	397	7.59	9.76	361.	MAY-09-56	188	24.3	SPECIAL STUDY
T016R50	604	12.4	9.68	358.	JUL-11-57	12	1.64	SPECIAL STUDY
T017R50H	384	12.2	9.87	365.	OCT-29-58	1140	107.	OSTEOSARCOMA, ULCER (MOUTH)
T018R50H	384	11.1	10.8	400.	OCT-29-58	1226	125.	OSTEOSARCOMA, ULCER (MOUTH)
T019R50H	384	11.3	10.7	396.	OCT-29-58	1219	123.	OSTEOSARCOMA, ULCER (MOUTH)
T020R50H	384	11.4	10.6	392.	OCT-29-58	1340	132.	CHONDROSARCOMA
T021R50H	382	11.8	10.1	374.	OCT-29-58	386	35.9	NEPHRITIS
T022R50H	382	11.9	10.1	374.	OCT-29-58	587	58.9	CRIPPLING FRACTURE
T029R50	474	13.5	10.4	385.	MAR-03-59	216	36.5	NEPHRITIS
T030R50	474	11.5	10.4	385.	MAR-03-59	178	30.5	NEPHRITIS
T031R50	471	10.5	10.4	385.	MAR-03-59	303	50.4	NEPHRITIS
T049R50	485	10.6	7.54	279.	MAY-02-63	5	0.85	SPECIAL STUDY
T050R50	485	13.7	7.46	276.	MAY-02-63	15	2.62	SPECIAL STUDY
T051R50	418	13.3	8.48	314.	MAY-08-63	92	18.1	SPECIAL STUDY
T052R50	418	10.7	8.57	317.	MAY-08-63	15	2.52	SPECIAL STUDY
T053R50	418	12.0	8.50	315.	MAY-08-63	33	6.18	SPECIAL STUDY
T054R50	416	11.4	8.76	324.	MAY-22-63	5	0.71	SPECIAL STUDY
T055R50	416	11.6	8.61	319.	MAY-22-63	33	5.50	SPECIAL STUDY
T056R50	416	11.6	8.61	319.	MAY-22-63	90	15.1	SPECIAL STUDY
T071R50	4025	13.8	9.23	342.	JAN-28-69	42	6.98	MELANOMA (MOUTH)
T072R50	4776	9.45	12.4	459.	AUG-17-72	54	12.6	SPECIAL STUDY
T115R50	572	11.4	8.74	323.	JUN-23-80	1	0.14	SPECIAL STUDY
T142R50+	2488	10.4	12.2	452.	JUL-12-84	96	14.3	SPECIAL STUDY
T143R50+	2478	10.8	12.2	450.	JUL-12-84	862	77.7	SPECIAL STUDY
T047R60	99	5.27	29.4	1090.	JUN-11-62	4	2.87	SPECIAL STUDY
T048R60	2843	11.2	25.1	929.	DEC-28-62	49	17.6	LEUKOPENIA, PNEUMONIA

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THE MULTIPLE INJECTION DOGS WERE MALE BEAGLES BORN IN DAVIS, CALIFORNIA, BUT INJECTED IN OUR LABORATORY. EACH WAS INJECTED SIX TIMES OVER A 280 DAY PERIOD WITH 56 DAYS BETWEEN EACH INJECTION. EACH RA-226 INJECTION WAS 740 KBQ (20.0 UCI) FOR THE DOGS T017R50H ... T022R50H; 237 KBQ (6.41 UCI) FOR T023R40H ... T027R40H; AND 96.6 KBQ (2.61 UCI) FOR T028R30H. TABULATED FOR EACH DOG IS AGE AT FIRST INJECTION, AVERAGE WEIGHT DURING THE INJECTION PERIOD, TOTAL UCI/AVERAGE WEIGHT, THE DATE OF FIRST INJECTION, THE TIME FROM FIRST INJECTION TO DEATH, AND THE SUM OF THE SKELETAL DOSES COMPUTED FROM EACH INJECTION TO DEATH.

B.22 ^{228}Ra (Mesothorium), Test Studies

DOG NUMBER	INJECTION: AGE (DAYS)	INJECTION: WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	INJECTION: DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001M45	528	9.13	4.23	157	SEP-08-54	314	15.2	CANINE DISTEMPER
T002M45	463	8.93	4.27	158	SEP-08-54	755	50.1	SPECIAL STUDY
T003M50	579	9.15	10.6	392	MAR-13-56	700	157.	ULCER (MOUTH), ANEMIA, CRIPPLING FRACTURE

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KBQ TH-228 / KBQ RA-228) INJECTED = 0.03.

B.23 ^{90}Sr, Test Studies

DOG NUMBER	AGE (DAYS)	WEIGHT (KG)	INJECTION		DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
			INJECTED (UCI/KG)	INJECTED (KBQ/KG)				
T001S00	151	7.71			MAR-05-54	112		SPECIAL STUDY
T008S00	243	7.00			NOV-04-54	0		SPECIAL STUDY
T008S20H	97	3.69	2.74	101.	SEP-27-55	66	0.14	SPECIAL STUDY
T009S20H	97	2.79	3.62	134.	SEP-27-55	66	0.19	SPECIAL STUDY
T010S20H	97	3.11	3.25	120.	SEP-27-55	132	0.45	SPECIAL STUDY
T011S20H	97	3.85	2.62	96.9	SEP-27-55	132	0.36	SPECIAL STUDY
T016S20	604	9.71	3.27	121.	NOV-08-61	9	0.04	SPECIAL STUDY
T021S25J	362	7.20	8.30	307.	OCT-02-63	13	0.94	SPECIAL STUDY
T012S30	593	10.6	10.5	389.	SEP-11-57	5	0.08	BREMSSTRAHLUNG PHANTOM
T013S40	324	10.5	19.1	707.	JUL-08-60	8	0.30	BREMSSTRAHLUNG PHANTOM, SAM MCGEE
T020S40J	440	8.54	28.9	1070.	OCT-02-63	13	0.52	SPECIAL STUDY
T002S50	149	6.85	148.	5480.	MAR-05-54	18	4.14	SPECIAL STUDY
T003S50	144	6.19	148.	5480.	MAR-05-54	28	6.34	SPECIAL STUDY
T004S50	151	7.05	148.	5480.	MAR-05-54	41	9.10	SPECIAL STUDY
T005S50	144	5.25	148.	5480.	MAR-05-54	116	23.3	SPECIAL STUDY
T006S50	155	7.01	87.0	3220.	MAR-16-54	1/24	0.01	SPECIAL STUDY
T007S50	155	6.74	87.0	3220.	MAR-16-54	2	0.28	SPECIAL STUDY
T014S50	542	10.0	96.1	3560.	NOV-07-61	9	1.07	SPECIAL STUDY
T015S50	595	9.43	98.4	3640.	NOV-07-61	30	3.33	SPECIAL STUDY
T022S50	545	9.01	99.0	3660.	APR-01-69	1525	86.6	HEMANGIOSARCOMA (SKELETON)
T023S50	545	11.6	100.	3700.	APR-01-69	1379	105.	OSTEOSARCOMA
T017S60	670	7.18	295.	10915.	JAN-19-62	14	4.66	LEUKOPENIA, THROMBOCYTOPENIA, PURPURA HEMORRHAGICA
T018S60	670	5.94	302.	11174.	JAN-19-62	1369	166.	HEMANGIOSARCOMA (SKELETON)
T019S60	670	5.43	284.	10508.	JAN-19-62	24	4.93	LEUKOPENIA, THROMBOCYTOPENIA

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T008S20 ... T011S20H WERE GIVEN 10 INJECTIONS, 37 KBQ (1 UCI SR-90) EACH AT WEEKLY INTERVALS. AGE IS AT FIRST INJECTION, WEIGHT IS AVERAGE DURING THE INJECTION PERIOD, KBQ/KG (UCI/KG) IS TOTAL SR-90/AVERAGE WEIGHT, DATE IS AT FIRST INJECTION. DAYS ARE FROM FIRST INJECTION TO DEATH, AND DOSE IS COMPUTED, FROM MID-INJECTION TO DEATH.

T020S40J RECEIVED 18.5 KBQ (0.5 UCI) SR-85 IN ADDITION TO THE 9130 KBQ (246.8 UCI) SR-90.
T021S25J RECEIVED 18.5 KBQ (0.5 UCI) SR-85 AND 22200 KBQ (600 UCI) SR-89 IN ADDITION TO THE 2210 KBQ (59.8 UCI) SR-90.

B.24 ^{228}Th, Test Studies

DOG NUMBER	INJECTION AGE (DAYS)	WEIGHT (KG)	INJECTED (UCI/KG)	INJECTED (KBQ/KG)	DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001M45	528	9.13	4.23	157	SEP-08-54	314	15.2	CANINE DISTEMPER
T002M45	463	8.93	4.27	158	SEP-08-54	755	50.1	SPECIAL STUDY
T003M50	579	9.15	10.6	392	MAR-13-56	700	157.	ULCER (MOUTH), ANEMIA, CRIPPLING FRACTURE

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KBQ TH-228 / KBQ RA-228) INJECTED = 0.03.

B.25 ^{232}U and/or ^{233}U, Test Studies

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T023U30	571	10.0	0.284	10.5	DEC-09-80	363		SPECIAL STUDY
T024U30	571	8.52	0.283	10.5	DEC-09-80	365		SPECIAL STUDY
T025U30	566	10.4	0.291	10.8	DEC-09-80	168		SPECIAL STUDY
T026U30	560	11.1	0.284	10.5	DEC-09-80	169		SPECIAL STUDY
T027U30	537	8.83	0.266	9.8	DEC-09-80	93		SPECIAL STUDY
T028U30	567	10.4	0.285	10.5	DEC-09-80	91		SPECIAL STUDY
T029U30	566	9.57	0.284	10.5	DEC-09-80	27		SPECIAL STUDY
T030U30	532	9.57	0.284	10.5	DEC-09-80	28		SPECIAL STUDY
T031U40	545	9.94	0.900	33.3	JAN-19-82	7		SPECIAL STUDY
T032U40	552	11.8	0.797	29.5	JAN-26-82	7		SPECIAL STUDY
T001U50	539	10.4	2.91	108.	FEB-23-76	94		SPECIAL STUDY
T002U50	524	12.0	2.91	108.	MAR-11-76	726		SPECIAL STUDY
T003U50	541	11.4	2.42	89.5	FEB-25-76	7		SPECIAL STUDY
T004U50	541	9.01	2.91	108.	FEB-25-76	14		SPECIAL STUDY
T005U50	541	9.08	2.96	110.	FEB-25-76	21		SPECIAL STUDY
T006U50	509	12.2	2.92	108.	FEB-25-76	364		SPECIAL STUDY
T007U50	667	10.4	2.77	102.	MAY-10-76	1		SPECIAL STUDY
T008U50	564	10.3	2.80	104.	APR-28-81	21		SPECIAL STUDY
T009U50	560	11.7	2.82	104.	APR-28-81	21		SPECIAL STUDY
T021U50	532	11.4	3.55	131.	DEC-09-80	7		SPECIAL STUDY
T022U50	566	8.39	3.52	130.	DEC-09-80	8		SPECIAL STUDY

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T023U30 THROUGH T030U30 RECEIVED U-232 ONLY.
T031U40 THROUGH T032U40 RECEIVED U-233 ONLY.
T021U50 RECEIVED 103 KBQ/KG (2.78 UCI/KG) OF U-232 AND 37.4 KBQ/KG (1.01 UCI/KG) OF U-233.
T022U50 RECEIVED 102 KBQ/KG (2.76 UCI/KG) OF U-232 AND 37.0 KBQ/KG (1.00 UCI/KG) OF U-233.

B.26 ^{238}U, Test Studies

DOG NUMBER	INJECTION: AGE (DAYS)	INJECTION: WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	INJECTION: DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001V01	567	11.3	0.00010	0.00370	NOV-16-76	2030		SPECIAL STUDY

B.27 X-Ray, Test Studies

DOG NUMBER	INJECTION: AGE (DAYS)	INJECTION: WEIGHT (KG)	INJECTION: INJECTED (UCI/KG)	INJECTION: INJECTED (KBQ/KG)	INJECTION: DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS	X-RAY EXPOSURE, R
T001XF	203				NOV-30-56	5775		SPECIAL STUDY	60
T002XM	201				NOV-28-56	4674		SPECIAL STUDY	90
T003XF	483				APR-11-60	5527		SPECIAL STUDY	82
T004XM	475				APR-11-60	3812		SPECIAL STUDY	68
T005XF	28				APR-04-60	5745		SPECIAL STUDY	84
T006XM	28				APR-04-60	121		SPECIAL STUDY	1.2

B.28 ^{210}Po, Test Studies

DOG NUMBER	INJECTION AGE (DAYS)	INJECTION WEIGHT (KG)	INJECTION INJECTED (UCI/KG)	INJECTION INJECTED (KBQ/KG)	INJECTION DATE INJECTED	POST INJECTION INTERVAL	DOSE TO SKELETON (GY)	COMMENTS
T001Z40	2501	12.3	3.39	125	JUL-12-84	470		SPECIAL STUDY
T002Z40	2495	10.9	3.37	125	JUL-12-84	243		SPECIAL STUDY
T003Z40	2465	12.1	3.18	118	APR-08-86	7		SPECIAL STUDY
T004Z40	2421	12.2	3.16	117	APR-08-86	28		SPECIAL STUDY

B.29 Ancillary Studies

DOG NUMBER	DAYS AGE AT DEATH	COMMENT
F001A00	1383	SPECIAL STUDY
F002A00	2492	SPECIAL STUDY, THYROIDITIS
M003A00	1451	SPECIAL STUDY
M004A00	3345	STATUS EPILEPTICUS
M005A00	3747	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER), NEPHRITIS
M006A00	5266	HEMORRHAGE (BRAIN)
M007A00	3895	LYMPHOSARCOMA
M008A00	3745	PARALYSIS (NO SKELETAL TUMOR)
F009A00	3719	FIBROSARCOMA (SOFT TISSUE)
F010A00	2605	SPECIAL STUDY
F011A00	4198	MAMMARY ADENOCARCINOMA, PULMONARY THROMBOEMBOLISM
F012A00	4218	ARTHRITIS
F013A00	4527	SPECIAL STUDY
F014A00	3777	THROMBOEMBOLISM
F015A00	4874	TRANSITIONAL CELL CARCINOMA (URINARY BLADDER)
F016A00	4415	SPECIAL STUDY
F017A00	2145	TRAUMA
F018A00	5921	NEPHRITIS
F019A00	4166	MAMMARY ADENOCARCINOMA
F020A00	2464	SPECIAL STUDY
F021A00	5508	MAMMARY ADENOCARCINOMA, THYROID CARCINOMA
F022A00	4350	LYMPHOSARCOMA
M023A00	1741	THROMBOEMBOLISM
M024A00	3074	SPECIAL STUDY
F025A00	5645	ISLET CELL TUMOR, PNEUMONIA
M026A00	4132	PERITONITIS, PANCREATITIS
M027A00	2129	SPECIAL STUDY
M028A00	3113	SPECIAL STUDY
M029A00	5016	MELANOMA (MOUTH)
F031A00	5265	STATUS EPILEPTICUS
F032A00	1990	LYMPHOSARCOMA
F033A00	3283	AMYLOIDOSIS (KIDNEY), PULMONARY THROMBOEMBOLISM
F034A00	2584	SPECIAL STUDY
M035A00	529	SPECIAL STUDY
M036A00	1971	SPECIAL STUDY
M037A00	4091	SPECIAL STUDY
F038A00	3802	MAMMARY ADENOCARCINOMA
M039A00	4406	THROMBOEMBOLISM
M040A00	4666	EPIDERMOID CARCINOMA (MOUTH), PNEUMONIA
F041A00	4704	LEIOMYOSARCOMA (SPLEEN)
M042A00	1265	STATUS EPILEPTICUS
F043A00	3883	SPECIAL STUDY, REASSIGNED-SEE T018P5
F044A00	5016	ADRENAL CORTEX CARCINOMA
F045A00	6182	PNEUMONIA, SENILITY

B.29 Ancillary Studies (continued)

DOG NUMBER	DAYS AGE AT DEATH	COMMENT
M046A00		REASSIGNED, SEE T048R60
F047A00	1732	SPECIAL STUDY
F048A00	5076	PANCREATITIS
F049A00	4773	ISLET CELL TUMOR, HEMORRHAGE (BRAIN)
M050A00	2263	SPECIAL STUDY
F051A00	1089	SPECIAL STUDY
F052A00	509	SPECIAL STUDY
F053A00	5520	THYROID CARCINOMA
F054A00	3190	SPECIAL STUDY, PYOMETRA
F055A00	4563	NEPHRITIS
M056A00	701	VOLVULUS, PERITONITIS
F057A00	4322	UNDIFFERENTIATED MALIGNANCY (ABDOMINAL CAVITY)
M058A00	767	SPECIAL STUDY
M059A00	567	SPECIAL STUDY
M060A00		REASSIGNED, SEE T071R50
M061A00	5511	RETICULOSARCOMA
F062A00	5348	THROMBOEMBOLISM
F063A00	4530	MAMMARY ADENOCARCINOMA, TRANS CELL CARCINOMA (URIN. BLADDER)
M064A00		REASSIGNED, SEE T045R30
M065A00		REASSIGNED, SEE T044R30
M066A00		REASSIGNED, SEE T040R10
M067A00		REASSIGNED, SEE T041R10
F068A00	4521	UNDIFFERENTIATED CARCINOMA (ABDOMINAL CAVITY)
F069A00		REASSIGNED, SEE T046R30
F070A00	5914	FIBROSARCOMA (SOFT TISSUE), NEPHRITIS
M071A00	1472	SPECIAL STUDY
M073A00	5695	DEGENERATION (ADRENAL GLAND), DIABETES MELLITUS
F074A00	5553	LYMPHOSARCOMA
M075A00	5283	THROMBOEMBOLISM
F076A00	5812	EPIDERMOID CARCINOMA (MOUTH)
F077A00	6047	RHABDOMYOSARCOMA, PAPILLARY CARCINOMA (OVARY)
F078A00	5110	HEPATIC CELL CARCINOMA
F079A00	4359	PNEUMONIA
F080A00	5419	LUNG CARCINOMA
F081A00	5921	LEIOMYOSARCOMA
M082A00	3627	LUNG CARCINOMA
F083A00	4988	INTESTINE SARCOMA
M084A00	5292	LYMPHOSARCOMA
M085A00	5498	CERVICAL SPONDYLOSIS
M086A00	498	SPECIAL STUDY
F087A00	4861	SPECIAL STUDY
F088A00		REASSIGNED, SEE T107W50
F089A00		REASSIGNED, SEE T074P40
F090A00		REASSIGNED, SEE T075P40

B.29 Ancillary Studies (continued)

DOG NUMBER	DAYS AGE AT DEATH	COMMENT
F091A00	4797	SPECIAL STUDY
F092A00	4799	SPECIAL STUDY
M093A00		REASSIGNED, SEE T076P40
F094A00		REASSIGNED, SEE T077P30
F095A00	4719	SPECIAL STUDY
F096A00	4373	HEMANGIOSARCOMA (SOFT TISSUE)
F097A00	4117	SPECIAL STUDY
F098A00	3752	MAMMARY ADENOCARCINOMA
F099A00	479	SPECIAL STUDY
M100A00	406	SPECIAL STUDY
M101A00	290	SPECIAL STUDY
F102A00	243	SPECIAL STUDY
M103A00	217	SPECIAL STUDY
M104A00	188	SPECIAL STUDY
F105A00	157	SPECIAL STUDY
F106A00	4324	SPECIAL STUDY
F107A00	4131	SPECIAL STUDY
F108A00	1969	ENCEPHALITIS
F109A00	2252	ENDOMETRITIS
F110A00		REASSIGNED, SEE T078P30
F111A00	2924	PNEUMONIA
F112A00	2942	SPECIAL STUDY
F113A00		REASSIGNED, SEE T123P20
F114A00	2591	SPECIAL STUDY
F115A00	2057	STOMACH CARCINOMA
F116A00		REASSIGNED, SEE F501P20+
F117A00		REASSIGNED, SEE F501R40+
F118A00		REASSIGNED, SEE F501P10+
F119A00		REASSIGNED, SEE F501P17+
F120A00		REASSIGNED, SEE F501P30+
F121A00		REASSIGNED, SEE F501R30+
F122A00		REASSIGNED, SEE F502P30+
F123A00	375	ACCIDENTAL STRANGULATION
F124A00		REASSIGNED, SEE F502P17+
F125A00		REASSIGNED, SEE F502P20+
F126A00		REASSIGNED, SEE F503P17
F127A00		REASSIGNED, SEE F503P20+
F128A00		REASSIGNED, SEE F502R40+
F129A00		REASSIGNED, SEE F503R30+
F130A00		REASSIGNED, SEE F504P1.7+
F131A00		REASSIGNED, SEE F502P1.0+
F132A00		REASSIGNED, SEE F501R5.0+
F133A00		REASSIGNED, SEE F503R4.0+
F134A00		REASSIGNED, SEE F503R3.0+

B.29 Ancillary Studies (continued)

DOG NUMBER	DAYS AGE AT DEATH	COMMENT
F135A00		REASSIGNED, SEE F502R5.0+
M136A00	3465	SPECIAL STUDY
F137A00		REASSIGNED, SEE F504R50+
F138A00		REASSIGNED, SEE F504P20+
F139A00		REASSIGNED, SEE F505P20+
F140A00		REASSIGNED, SEE F505P17+
F141A00	1830	PANCREATITIS
F142A00		REASSIGNED, SEE F503P10+
F143A00		REASSIGNED, SEE T176W30+
F144A00		REASSIGNED, SEE F504R40+
F145A00		REASSIGNED, SEE F503R50+
F146A00	3202	SPECIAL STUDY, PANCREATITIS
F147A00		REASSIGNED, SEE F506P17+
F148A00	1801	SPECIAL STUDY
F149A00	4317	SPECIAL STUDY
F150A00	4385	SPECIAL STUDY
F151A00	4205	SPECIAL STUDY
F152A00	568	SPECIAL STUDY
F153A00	4282	SPECIAL STUDY
F154A00		REASSIGNED, SEE F513R40+
F155A00	2931	SPECIAL STUDY, PANCREATITIS
F156A00	2406	NOSE ADENOCARCINOMA
F157A00	2603	SPECIAL STUDY
F158A00		REASSIGNED, SEE T242P30+
F159A00		REASSIGNED, SEE T243P30+
F160A00		REASSIGNED, SEE T211P20
F161A00	3926	SPECIAL STUDY (MAMMARY ADENOCARCINOMA)
F162A00	3926	SPECIAL STUDY
F163A00	1257	SPECIAL STUDY
F164A00		REASSIGNED, SEE T206P20
M165A00	92	SPECIAL STUDY
M166A00	388	SPECIAL STUDY
F167A00	369	SPECIAL STUDY
M168A00	517	SPECIAL STUDY
M169A00	513	SPECIAL STUDY
M170A00	510	SPECIAL STUDY
M171A00	95	SPECIAL STUDY
F172A00	518	SPECIAL STUDY
F173A00	89	SPECIAL STUDY
F174A00	94	SPECIAL STUDY
F175A00	520	SPECIAL STUDY
F176A00	521	SPECIAL STUDY
M177A00	3420	SPECIAL STUDY
M178A00	1186	SPECIAL STUDY

B.29 Ancillary Studies (continued)

DOG NUMBER	DAYS AGE AT DEATH	COMMENT
M179A00	4125	SPECIAL STUDY
F180A00	3653	SPECIAL STUDY
M181A00	1211	SPECIAL STUDY
M182A00	196	SPECIAL STUDY
M183A00	3064	SPECIAL STUDY
F184A00	184	SPECIAL STUDY
M185A00	524	SPECIAL STUDY
M186A00	189	SPECIAL STUDY
F187A00	93	SPECIAL STUDY
F188A00	193	SPECIAL STUDY
F189A00	262	SPECIAL STUDY
F190A00	372	SPECIAL STUDY
F191A00	176	SPECIAL STUDY
M192A00	91	SPECIAL STUDY
M193A00	369	SPECIAL STUDY
F194A00	371	SPECIAL STUDY
M195A00	362	SPECIAL STUDY
M196A00	1168	SPECIAL STUDY
M197A00	275	SPECIAL STUDY
F198A00	274	SPECIAL STUDY
M199A00	279	SPECIAL STUDY
M200A00	263	SPECIAL STUDY
F201A00	267	SPECIAL STUDY
M202A00	4150	SPECIAL STUDY
F203A00	3546	SPECIAL STUDY
M204A00	182	SPECIAL STUDY
F205A00	91	SPECIAL STUDY
F206A00	3759	SPECIAL STUDY, AMYLOIDOSIS (KIDNEY)
F207A00	3729	SPECIAL STUDY
M208A00	797	SPECIAL STUDY
M209A00	782	SPECIAL STUDY
M210A00	4403	SPECIAL STUDY
F211A00	2368	SPECIAL STUDY, STATUS EPILEPTICUS
F212A00		REASSIGNED, SEE T207P20
F213A00		REASSIGNED, SEE T208P20
F214A00		REASSIGNED, SEE T209P20
F215A00	3528	SPECIAL STUDY
F216A00	3334	MAMMARY ADENOCARCINOMA
F217A00		REASSIGNED, SEE F514R40+
F218A00	3910	SPECIAL STUDY (CHRONIC PANCREATITIS)
F219A00	3884	SPECIAL STUDY
F220A00	3836	SPECIAL STUDY
F221A00		REASSIGNED, SEE T212P20
F222A00		REASSIGNED, SEE T183W30

DOG NUMBER	DAYS AGE AT DEATH	COMMENT
F223A00		REASSIGNED, SEE T142R50
F224A00		REASSIGNED, SEE T143R50
F225A00	623	SPECIAL STUDY
F226A00	616	SPECIAL STUDY
M227A00	557	SPECIAL STUDY
M228A00	553	SPECIAL STUDY
F229A00		REASSIGNED, SEE T139R30+
F230A00	1586	UNDETERMINED
F231A00		REASSIGNED, SEE T135R30+
F232A00		REASSIGNED, SEE T003Z40
F233A00	2657	SPECIAL STUDY
F234A00		REASSIGNED, SEE T137R3.0+
F235A00		REASSIGNED, SEE T141R30+
F236A00		REASSIGNED, SEE T004Z40
F237A00	2697	SPECIAL STUDY
F238A00		REASSIGNED, SEE T181W30
F239A00		REASSIGNED, SEE T184W30
F240A00		REASSIGNED, SEE T136R30+
F241A00	2456	SPECIAL STUDY
F242A00	2378	SPECIAL STUDY
F243A00		REASSIGNED, SEE T310P20
F244A00		REASSIGNED, SEE T182W30
M245A00	2067	SPECIAL STUDY
M246A00	2077	SPECIAL STUDY
F247A00	1397	SPECIAL STUDY
F248A00	1358	SPECIAL STUDY
F249A00	1344	SPECIAL STUDY
F250A00		REASSIGNED, SEE T186W30
F251A00	1307	SPECIAL STUDY
F252A00	1252	SPECIAL STUDY
F253A00	1275	SPECIAL STUDY
F254A00	1231	SPECIAL STUDY
F255A00	1300	SPECIAL STUDY
F256A00	1092	SPECIAL STUDY
F257A00	1078	SPECIAL STUDY
F258A00	1084	SPECIAL STUDY
F259A00	1152	SPECIAL STUDY
F260A00	1104	SPECIAL STUDY

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